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TRANSACTIONS

OF THE

Illinois State Academy of Science

THIRD ANNUAL MEETING

URBANA, ILL., FEB. 18 AND 19, 1910.

VOLUME III

1910

PUBLISHED BY THE ACADEMY

OHIO STATE UNIVERSITY

Price, Paper Binding, 75c; Cloth Binding, $1.00

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EDITED BY
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TRANSACTIONS

THIRD ANNUAL MEETING.

HALL OF CHEMISTRY, UNIVERSITY OF ILLINOIS.
URBANA, FEBRUARY 18 and 19, 1910.

SESSION OF FRIDAY FEBRUARY 18.

AFTERNOON.

President Forbes called the meeting to order at 2:15 and announced that the first item of business would be reports of officers. The Secretary presented the following report:

SECRETARY'S REPORT.

The reading of the minutes of the last meeting and of the council meeting may be dispensed with since they are reported in Vol. II of the Transactions, a copy of which has been sent to all members whose addresses are known.

The secretary will be obliged if any one can give the addresses of the following: Baird, L. P.; Collett, E. B.; Collier, J. S.; Dawson, L. A.; Haddock, F. D.; Montgomery, O. C.; Putnam, J. R.; Winter, S. G.

Publication of the last volume of the Transactions was delayed, since the committee which was appointed to ascertain whether or not the State would publish our papers was long kept in doubt by the condition of business in the legislature. Seeing no hope of favorable consideration during the current session, the committee decided not to make the request but to postpone action till a more favorable time. As soon as that decision was reached, the secretary began to collect material for the volume.

At another time the Transactions can be brought out more

promptly. When not handicapped by the necessity of haste, the appearance and character of the volume can be improved.

At this third annual meeting it is gratifying to note that the Academy has 275 active, six corresponding and one honorary members—a total of 282 members. The membership committee and individual members of the Academy have been busy in adding to our list and before the organization is five years old we shall no doubt enroll 500 names.

In order that the Academy might be known to people who on the one hand should obtain the advantages of membership and on the other hand should advance its interests, the secretary by correspondence obtained the names of over 1100 teachers of science in the public schools, normal schools, colleges and universities of the State. A card catalog of these has been prepared and one or more announcements, programs, list of members, etc., sent to them.

To 700 newspapers in the State special notices of this meeting have been sent. Separate articles have been written for some papers upon request of the editors, and several hundred letters have been written to individual members. Altogether more than 4,000 notices have been sent out during the last two months. This extra effort has been made because of a realization of the many claims which clamor for the attention, time and finances of men of science, and because of the conviction that to be widely known and numerously supported, the Academy must be brought prominently to the notice of acceptable candidates.

Men engaged in teaching are usually engrossed with students, laboratories and their immediate institution, and give hardly a passing thought to the larger circle.

The Academy affords a means of extending the circle of influence of each individual member to *non-academic territory*. There is a work of magnitude to be performed in this State; a work which men of your education and men with your knowledge can best advocate; a work which can be accomplished, not by individuals but by an organization; a work

which will contribute to the general prosperity and happiness of the people of the commonwealth.

The larger our association, the more effective our influence. May not each one of us constitute a membership committee to bring in acceptable candidates until the roll of members will be a well nigh complete roster of the scientific workers of the State.

Respectfully submitted,

A. R. CROOK, Secretary.

It was voted that the Secretary's report be accepted and placed on file.

The Treasurer presented the following report:

TREASURER'S REPORT.

ILLINOIS ACADEMY OF SCIENCE.

Feb. 18, 1910.

Balance on hand Feb. 10, 1909	$123.83	
Receipts from Initiation Fees and Dues	219.20	
Total	$343.03	$343.03
Disbursements made upon order of President and Secretary	$141.03	$141.03
Balance on hand *Feb. 15, 1910*		$202.00

Respectfully submitted,

JOHN C. HESSLER,
Treasurer.

Upon motion of Stuart Weller the Treasurer's report was placed on file and upon motion of T. C. Chamberlin the chair appointed the following auditing committee: W. S. Strode and T. L. Hankinson.

T. W. Galloway presented for the membership committee a list of candidates and they were unanimously elected to membership. The list of all members elected during the meeting is given on page 156.

Thereupon the presentation of papers was taken up. A. R. Crook read a paper as follows:

DR. AMOS WILLARD FRENCH: IN MEMORIAM.

As far as the writer is aware Dr. French of Springfield is the first member of the Academy to be removed from our number by death. Many may remember him as the gentleman with white hair and beard, evidently the veteran among those present at the organization meeting of the Academy in Springfield, December 1907, who spoke of the value of scientific work and expressed the hope that the Academy might be a means of increasing the influence of science in the State.

At the time of his death he was nearly eighty-eight years of age, was the oldest alumnus of Washington University, St. Louis, and the oldest practicing dentist in the United States. Many residents of Springfield had never employed any other dentist.

To me he was an interesting personality especially because of youthful interest in things, in men and in ideas. Intellectually he was emancipated from many of the bonds which restrain thought and discourage mental progress and hence he retained a receptive and creative attitude of mind which was intellectually life giving. From early times he was interested in many things outside of his profession. Among his particular friends were A. H. Worthen, who, as State Geologist or Curator of the State Museum for thirty years, left his impress on the geology of the region; and Major J. W. Powell, first widely known for his exploration of the Colorado River, and later as the Director of the U. S. Geological Survey. With such friendships, French naturally was greatly interested in geology, and gave much time to its study, collecting a fine geological library and bringing together an extensive assemblage of minerals and rocks. Thought on geological subjects and discussions of related questions gave him great pleasure and, as is often the case, the result of such first-hand information and contact with actual facts enabled him to free his mind of many of the

clouds which darken reason and to see clearly in paths where his contemporaries darkly grope.

The record of his life reads:

Born at Brighton, New York, July 24, 1821. Died at Springfield, Illinois April 27, 1909. Graduated at Washington University (Missouri Dental College) 1867. Married Sarah T. Foster 1851. His four daughters grace the communities in which they reside. Member of Board of Trustees and of Building Committee of Springfield City Library; Secretary of the Capitol Building Co., which built the first street car line in city. Interested in building the Leland Hotel and Watch Factory. One of six founders of the Bettie Stuart Institute and till the time of his death, President of Board of Trustees. Active in meetings of dentists, in a Springfield scientific society, in the State Historical Society, and in college gatherings. A public spirited citizen, a fine gentleman, a man whose loss even the most recent of his acquaintances sadly deplore. With sorrow we record his death.

W. A. Noyes moved that the paper be filed with the Secretary and a copy sent to the relatives of Dr. French.

T. W. Galloway then presented the following paper:

A WORK NEEDING TO BE DONE BY THIS ACADEMY.

I presume we are agreed that the chief function of a miscellaneous association of scientists such as this lies in the synthesis of our work and in the suggestion of cooperation among us. The academy offers the machinery for a kind of *state consciousness* in respect to scientific matters. Another function, partly incidental to this and partly new, has been suggested from time to time:—viz., the encouragement and increased efficiency of the amateur, or *independent isolated* worker, who lacks the guidance both as to method and matter which is possible to students of experience on the one hand or to those immediately guided in the university on the other.

To the latter of these two functions of the academy I want to direct a few remarks; and I will become concrete at once.

In Biology as in other sciences, there are certain lines of work which cannot be pursued to advantage by the student away from laboratories and libraries. On the other hand, there are certain problems of extension, of behavior and relation—i. e. of distribution and ecology—which are quite open to such study. As a matter of fact our present situation calls for thousands of just such scattered or distributed studies.

Furthermore, if we can bring these *needs* clearly to the consciousness of the workers, there are probably hundreds of possible workers who would find it a pleasure to do something, if they only knew what to do and how to go about it.

For these reasons the conviction has been growing on me, since the organization of this Academy, that we can do something in the *conservation* line ourselves; and that the time has come when a wise committee, who does not want a monopoly of the honor of doing the scientific work of the state themselves, could render a tremendous service to the great body of biological workers who may not be quite equal to self-guided work; and at the same time advance the knowledge of Illinois biology.

In my own observation of conditions it appears to me that the lack of initiative on the part of many who might be adding to our knowledge arises from the following things:

1. They do not know what has been done and fear that their efforts would be wasted.
2. Hence, they do not know what are considered the needful things to be done, and where to put their energies.
3. They quite probably are uncertain as to the best mode to proceed to accomplish something which would really contribute to knowledge.

I hasten to say that I am not assuming that the Academy can make finished scientists of these; but merely that a conservation of scientific energy can be secured, and that actual additions may be made to our knowledge which might escape the finished scientists for years.

Briefly, the work that I am suggesting at the hands of such a committee would consist (1) in the preparation of a bulletin which would, in some degree, indicate some of the most significant gaps that exist, in whose closing amateur investigators might readily take part, and (2) the distribution of this bulletin to all teachers of biology and physiography and geology in our high schools and colleges and to interested observers everywhere.

More specifically, such a bulletin should contain:

1. A statement of the fields in which the best work has already been done in Illinois biology of the kind already referred to as suitable to the amateur worker. This would not be a tremendously large task.

2. An analytic display of the fields of work in which the best possibilities now open to such workers. This analysis should go on down even to the statement of some particular problems, of suitable dimensions for unguided workers.

3. A somewhat detailed outline of proper methods of procedure in one or two concrete problems, either of some work already done or of some still needing to be done. Stress should here be put on the attitude of mind necessary to successful scientific work.

4. Citations to some of the very best literature of any region illustrative of proper method and spirit in such work.

5. A good classified bibliography of Illinois titles of biological literature pertaining to the types of work outlined as feasible.

Such a bulletin would prove useful to many people perfectly competent to work, who for one reason or another are not quite equal to wise selection of a field of study or to complete self-guidance after it is chosen. This kind of exploitation of the field would make it possible for many teachers in schools and colleges to use their classes in the getting of needed data, incidentally much to the benefit of the courses they are giving.

This proposition would call, as a second step of course, for a bureau of some sort to whom the results—whether of material or of observations—may be returned and there edited, collated,

and published if need be. The State Biological Survey suggests itself to me as the appropriate agency, for this is largely the very purpose of its existence. In this way the Academy, on the biological side, would become the field representative of the Survey. The Survey would become an executive committee and guiding spirit of our Illinois workers in biology —in so far as our work is geographical.

This Committee would need (1) a member who knows well what has been done and what needs to be done in the state; (2) a member who would be good at an analytic statement of the problems and opportunities, in detail: and (3) a member full of sympathy and knowledge of the limitations and possibilities of the grade of biological workers for whom these suggestions are spoken.

John M. Coulter said in substance.—"One of the functions of a State Academy has been well indicated by the gentleman who just spoke. He has given an idea worth following out. It has been my experience—and I have been attending State Academies for many years, having recently been present when the Indiana Academy held its silver wedding—that one of the chief reasons for our meeting together is not to read papers, but to hold a fellowship conference. We can read the papers at home. We all may be fired by attending an enthusiastic meeting.

F. C. Baker.—"Could not these amateur workers under proper directions assist in the general ecological study of Illinois by contributing notes and data on the natural history of their immediate home region. These notes could be correlated with the work of the trained workers."

S. A. Forbes.—"This subject of Prof. Galloway's paper may come up later when the report is presented by the ecological committee.

H. A. Gleason presented an illustrated paper of which the following is an abstract.

THE VEGETATIONAL HISTORY OF A BLOWOUT.

Blowouts are saucer-shaped or bowl-shaped excavations caused by the action of wind on sand which is not sufficiently protected by a plant covering. They may reach in Illinois a length of 200 yards or more, and a depth of 10 to 30 feet.

They consist of four physiographic divisions, with each of which a definite association is correlated. The windward slope, occupied by the windward slope association, is situated at the west end of the blowout. On it the sand is being removed by wind and is also sliding down by gravity. The vegetation is composed principally of grasses derived from the vegetation outside the blowout. The deepest part of the blowout is the basin, from which sand is being removed by wind alone. The basin association is composed of a few individuals of deep-rooted perennials. The upward slope at the east side of the basin is called the lee slope. On it the sand is merely in motion, without any essential change in level. It is occupied by the blowsand association, consisting of large numbers of slender, quick-growing annuals. The east end of the blowout is occupied by the deposits, on which sand is being piled by the wind. The vegetation of the deposit association is principally composed of sand-binding perennials, through the agency of which the sand is accumulated into dunes.

The successional relations of these four associations are complex, but lead as a rule to the ultimate dominancy of the blowsand association. When the sand has ceased blowing, stabilization of the blowout begins in all four parts, and the area is soon reoccupied by a more luxuriant vegetation.

C. C. Adams presented a paper which is given below in abstract.

RECENT HABITAT CHANGES IN THE ILLINOIS RIVER.

This paper is a report of an ecological reconnoissance of the Illinois River at Havana carried on by the cooperation of the State Laboratory of Natural History and the Ecological Survey Committee of the State Academy of Science.

During recent years the increased amount of water in the river has raised the water level about 3 feet. This has submerged the lowlands, killed many trees and produced numerous changes in the animal habitats. The paper describes some of the changes observed in 1909 and compares them with conditions previous to the high water.

A. R. Crook inquired concerning the cause of the sudden changes in the height of water as shown by the "lily pads" left standing and the changes in the amount of vegetation in the waters of the region described, from year to year.

C. C. Adams replied that Prof. Forbes could answer the questions.

Mr. Forbes said that the cause of the changes were extremely complex and necessitated close study for a series of years, study which was being prosecuted by the survey.

W. S. Strode.—"This paper touches me in a tender spot. The Thompson lake region so ably portrayed is my old stamping ground, and I have explored every foot of it. It is the richest faunal region in the state or anywhere else; rich in shells, fishes, birds, plants, aquatic life of all kinds. The turning in of the drainage ditch water a few years ago made a great change; plants and trees died; there are hundreds of acres of dead trees all about the lake. The lake is high water now all the time. A few years ago one could wade across it. This lake at one time during a very low period nearly caused the death of all the unios or fresh water mussels it contained, almost car loads of them indeed and windrows of the dead shells extended all the way around the lake, and it looked like the extinction of

a very interesting species, *anodonta suborbiculata*, perhaps the handsomest of all mussels and quite scarce every where except in this lake. The late state geologist Worthen discovered this beautiful unio in this lake and kept it a secret for many years, sending specimens to nearly every museum in the world, and to many private collections. There are plenty of them in the lake now but they keep to the southern half of the body of water, while a companion almost equally interesting, *anodonta corpulentii*, holds possession of the northern half.

This lake is also headquarters of a bird that is the gem of the swampy place—the prothonatory warbler, which builds always over the water in holes of old stumps or trees and uses only green moss for nest material.

Water birds of all kinds are abundant in this region. On December 12th last, one of the stormiest days of the month, my father and I killed the legal limit of red-legged mallards in a few hours. Many other animals are to be found here. On one excursion four big water snakes dropped from over-hanging willows into my boat.

It was here that I first met the essayist Mr. Adams and also some years ago discovered a big man in rough wading clothes and big sun hat in water up to his arm-pits and on inquiring of some fishermen who it was got the reply that he was an old crank soldier, a little queered. Further investigations disclosed the fact that it was the now honored president of the Illinois Academy of Science, Stephen A. Forbes, one of the most noted scientific investigators in the world.

Mr. Forbes.—"In locating our station on the Illinois river we were fortunate in having the acquaintance of a man who from his boyhood had been familiar with the region—Dr. Strode."

William S. Cooper then gave an illustrated paper of which the following is an abstract.

PRELIMINARY ACCOUNT OF THE FOREST SUCCESSIONS ON ISLE ROYAL, LAKE SUPERIOR.

Isle Royal, an island near the northwest shore of Lake Superior, is fifty miles long and six to ten miles wide. Its topography is determined by a parallel series of tilted beds of Keweenawan and Cambrian age, which dip southeast under Lake Superior. The result of this structure is a series of ridges extending northeast and southwest, parallel to the long axis of the island, with steep faces on the northwest, but sloping gently to the southeast. The ridges bound long narrow valleys which contain bogs and lakes, or harbors if below the present lake level.

The island was overridden by the continental glacier, and on the retreat of the ice was left entirely submerged beneath the waters of Lake Duluth. As the lake level subsided the island gradually emerged, finally reaching its present size. It has never been connected with the mainland since glacial times.

The dominant forest of the island is composed of white spruce, paper birch, and balsam fir. Whether this is the climax forest toward which the earlier successional stages tend cannot be determined at present. The uncertainty is due to two causes: the presence on the southwestern end of a well developed forest of sugar maple, which is the most important tree of the climax forest farther south; and the apparently unstable character of the dominant forest. It can be said with certainty, however, that the successional stages lead to the spruce-birch-balsam forest. Whether this in turn will tend to become maple forest is the doubtful point.

The devil's club (*Fatsia horrida*), first discovered on the island by W. A. Wheeler, was found in four isolated localities in the forest at the northeast end. It is a very common plant in the western mountains and is known nowhere in the east except on Isle Royal.

There are two main lines of normal succession leading to the spruce-birch-balsam forest as their ultimate or penultimate stage: the rock shore series and the lake bog series.

The rock shore succession is made up of the following stages: 1, crustose lichen stage; 2, crevice plant-lichen stage (Fig. 1); 3, Cladonia-Juniperus stage; 4, mature forest. The abrupt transition from the comparatively youthful third stage to the mature forest may perhaps be explained by the former presence of intermediate societies which have been "pinched out" by the advance of the forest toward the lower limit of plant growth, at the present time practically stationary, which is determined by wave action and ice. Suggestions of a xerophytic transitional society, dominated by jack pine, were found at a few points by Adams.

The lake bog series develops in the valleys and depressions which have been shut off from the main lake by the emergence of the island. The early stages are as follows: 1, aquatic stage; 2, bog sedge stage; 3, bog shrub stage. From this point two types of bogs develop. The first, in undrained depressions, is characterized by abundance of sphagnum and heaths, especially Labrador tea, followed by bog forest composed of tamarack and black spruce. The second type (Fig. 2), developing in basins possessing active inlets and outlet, is characterized by practical absence of sphagnum. The shrub zone is made up of Chamaedaphne and alder, and the bog trees following are tamarack and arbor vitæ. The condition and causes of the two bog types are still to be worked out. Both types develop into the spruce-birch-balsam forest, usually very soon after the bog forest is mature.

The changes brought about in the dominant forest by fires are as follows. If the humus is completely burned from the rocks, a succession is instituted which is essentially like the rock shore succession. If more or less of the humus and forest vegetation remain, certain species develop to the exclusion of the rest, and dominate for a time. The balsams are exterminated, while the birches increase enormously by sprouting from the stump. The result is a birch forest, under the

shade of which the spruces and finally the balsams develop, the ultimate result being a return to the spruce-birch-balsam type of forest.

J. C. Hessler.—"What is the character of the rocks on Isle Royal?"

W. S. Cooper.—"They belong to the Keweenawan and Cambrian."

J. C. Hessler.—"I have a series of photographs taken on Silurian formations several hundred miles south of Isle Royal which show the same topography and same general type of vegetation."

T. C. Chamberlin.—"There is no doubt a calcareous factor influencing the character of the vegetation."

J. G. Coulter.—"Mr. Cooper's interesting chart, indicating tree successions on the basis of contrast of ages evidenced by growth rings, suggests the old question of the dependability of these rings as indicative of annual increments. Of course even large fluctuations from the year-value would not, however, invalidate Mr. Cooper's striking chart, which is constructed upon a comparative rather than an absolute basis.

In tropical trees the question of the time-value of these rings is more complex. The interesting fact is that these rings are readily discernible in many tropical woods, although not so clearly marked as in trees of the temperate regions. In the Philippine Islands, for example, such rings have been observed in the wood of members of the Leguminosae and of the Dipterocarpeae. In the former, a year-value suggests itself since these trees do regularly lose the bulk of their foliage in monsoon-forests during the dry season. In the latter case, however, the time-value is more perplexing since there is no evident general loss of foliage at any time of year, nor do the climatic variations indicate any necessity for a stoppage or even any serious pause in nutritive activities during the year. at least not in the case of deep rooted old trees. However the rings appear to be as well marked near the bark as near the core of such trees.

Fig. 1.

Fig. 1. Lichen and crevice plant societies on shore rocks. *Potentilla tridentata* as crevice plant.

Fig. 2.

Fig. 2. Bog of drained depression type. Sedge zone in foreground with pitcher plant and Alpine cotton-grass; alder and chanaedaphne in center and in front of trees; open water and aquatics at right; tamaracks behind, with spruce-birch-balsam forest on high ground at right.

I would like to ask Mr. Cooper whether, under the climatic conditions of Isle Royal, there is not good reason to believe that these rings have practically an absolute year-value?"

Mr. Cooper.—"No attempt was made to study that subject, but in a general way the method yields fairly accurate results."

W. S. Bayley called attention to the fact that the more intelligent woodsmen on the neighboring mainland believe that the rings indicate the ages of the northern trees, basing their belief upon the fact that the positions of several double sets of rings seen in almost all trees correspond accurately to the dates of several seasons, when the trees budded twice.

He also stated that the rocks on Isle Royal comprise a series of sandstones, conglomerates and lavas of very different compositions. The Cambrian, on the south side of the island, is almost a pure quartzite. The same types of rocks occur in that portion of Minnesota north of Lake Superior, and so far as known there is no difference in the character of the forest corresponding to differences in the character of the rock. He asked the speaker if the forest covering over the Cambrian quartzite on Isle Royal was noticed to be different from that over the Keweenawan beds.

Mr. Cooper.—"The forests on the different formations seemed to be of the same general type."

T. L. Hankinson presented the following paper:

AN ECOLOGICAL STUDY OF THE FISH OF A SMALL STREAM.

In this paper I will attempt to set forth the nature of my studies of the fish life of the streams about Charleston, Ill., by considering some of the methods employed and the results obtained in investigating the fish of a particular stream, called by a few of us "Campus creek" because a portion of its water comes from the Normal School campus. Although more or less attention has been given to this stream for about six years, a systematic investigation of its fauna and flora has been

carried on for about three years. The work is but fairly begun; and this paper by no means represents a culmination point in the accumulation of facts concerning this body of water.

Campus creek meanders in a southerly and westerly direction through pasture and cultivated fields and thickets, keeping to the south side of its rather broad valley, which reaches a width of about a half mile near the mouth of the stream. The country along the sides of this valley is high and gently rolling morainal region. Like other streams about Charleston, Campus creek is a part of the Wabash system, its waters entering this river through the Embarras river and Kickapoo creek. To the latter stream it is a tributary. Campus creek has four principal branches, all of which flow in a southerly direction, entering the main stream on its north side. The different portions of this little system vary considerably as to direction and rate of flow, width of bed, depth of water, topography of bottom and shore, and biological conditions present.. Throughout most of its course it is broken into a series of pools with intervening narrows or broad shoals. The average maximum depth of these pools seems to be about two feet, but a few have depths as great as three feet. The current is swift in narrows and about perceptible in pools. The water is very clear under ordinary conditions. The bottom is, for the most part, firm and light-colored, composed of various combinations of clay, sand, gravel, and cobble stones. Small boulders are not infrequent in the stream bed. In the deeper parts of pools, a thin, dark sediment, rich in humus, often covers the bottom. Dead leaves accumulate here, also, in many cases. The bank in most places is grassy, and the long blades often completely conceal narrow stretches of the stream. Many kinds of plants grow along the shore, but distinctly aquatic seed plants are scarce. The stream is rich in algæ, and these organisms are being studied by Mr. Transeau. Diatoms produce a brownish scum over submerged stones, sticks, and other objects as well as over some areas of the bottom soil. This scum is especially noticeable in early spring.

An attempt has been made to get a complete collection of

invertebrate animals from each collecting station along the stream, and notes on the habits of these forms are being made as well as upon fish, but at present no detailed report upon them can be made. Campus creek is a good crayfish steam. Amphipods and isopods are common in its headwaters and those of some of the larger tributaries. Snails of several kinds are numerous. Such aquatic insects as dragon-fly larvæ, damsel-fly larvæ, and caddice worms are abundant, and some interesting problems concerning these and other invertebrate forms have presented themselves. Of the species of aquatic vertebrates other than fish, no one is abundantly represented. Crickets frogs, *Acris gryllus* LeConte, leopard frogs, *Rana pipiens* Schreber, and green frogs, *Rana clamitans* Latreille, are found in numbers in spring. Careful search has failed to reveal any amphibian eggs in any part of the stream, and tadpoles are scare at all seasons. Only one turtle, a large snapping turtle, *Chelydra serpentina* Linnæus, has been seen by me about the creek. Water snakes, *Natrix sp.*, are now and then noted, and are especially common in late spring. The following water birds have been recorded by me from different parts of Campus creek system Carolina rail, *Porzana carolina*, king rail, *Rallus elegans*, Wilson's snipe, *Gallinago delicata*, spotted sandpiper, *Actitis macularia*, green heron, *Butorides virescens*, and American bittern, *Botaurus lentiginosus*.

Of the fifty-four species of fish found to my knowledge about Charleston, seventeen are represented in Campus creek. A list of these, using the names employed in the recent work on the Fishes of Illinois by Dr. Forbes and Mr. Richardson, is here given:

Chub sucker, ***Erimyzon sucetta oblongus*** (Mitchell).
Stone roller, ***Campostoma anomalum*** (Rafinesque).
Black-head minnow, ***Pimephales promelas*** Rafinesque.
Blunt-nosed minnow, ***Pimephales notatus*** (Rafinesque.)
Horned dace, ***Semotilus atromaculatus*** (Mitchell).
Golden shiner, ***Abramis chrysoleucas*** (Mitchell).
Straw-colored minnow, ***Notropis blennius*** (Girard).
Silverfin, ***Notropis whipplii*** (Girard).
Common shiner, ***Notropis cornutus*** (Mitchill).
Blackfin, ***Notropis umbratilis atripes*** (Jordan).

Black bullhead, *Ameiurus melas* (Rafinesque).
Silver-mouthed minnow, *Ericymba buccata* Cope.
Yellow bullhead, *Ameiurus natalis* (LeSueur).
Blue-spotted sunfish, *Lepomis cyanellus* Rafinesque.
Black-sided darter, *Hadropetrus aspro* (Cope and Jordan).
Johnny darter, *Boleosoma nigrum* (Rafinesque).
Rainbow darter, *Etheostoma caeruleum* Storer.

Of these only seven may be considered common and permanent inhabitants of the stream. These are, named in the order of their apparent abundance: stone roller, blunt-nosed minnow, horned dace, blue-spotted sunfish, black head minnow, silver mouthed minnow, and chub sucker. The following have been noticed common at particular times only: silverfin, common shiner, and black bullhead. Species that have been recorded in a very few instances and which are certainly very scarce in the creek are: straw-colored minnow, blackfin, yellow bullhead, and each of the three kinds of darters that have been seen in the stream. There are some species common in Kickapoo creek that I have never notd in Campus creek, although some of them, at least, probably come into it at times in the vicinity of its mouth. These are: hog-nosed sucker, *Catostomus nigricans* LeSueur, white sucker, *Catostomus commersonii* (Lacepede), red horse, *Moxostoma aureolum* (Le Sueur), sucker-mouth minnow, *Phenacobius mirabilus* (Girard), brindled stone cat, *Schilbeodes miurrus* (Jordan), common top minnow, *Fundulus notatus* Rafinesque, and green sided darter, *Diplesion blennioides Rafinesque.* On the other hand, a few species seem to prefer Campus creek to the larger Kickapoo creek. These are the horned dace, black head minnow, chub sucker, and blue-spotted sunfish. Species found in numbers in both streams are: stone roller, blunt-nosed minnows, silver minnows, and silverfin.

The chief problem under consideration, concerning the fish, in this work on Campus creek and on other steams about Charleston is to determine the local distribution of each species, the type of habitat that it prefers and the way it is related to its surroundings. When these habitats are discovered, a successional study of them can be made. The rapidly changing

Fig. 3. Nesting habitat of stone roller.

Fig. 4. Nesting habitat of horned dace.

conditions in Campus creek due to freshets and other causes render the stream very favorable for such work.

To find these preferred habitats is difficult on account of the great variation in distribution of fish noted at different times. There are not only annual and seasonal fluctuations in numbers, but also daily and even hourly ones. Often they can be correlated with changing environmental conditions but in many cases, they can not be. An abundance of statistical data for each type of habitat is needed, but this is not easy to obtain even under the specially favorable conditions afforded by a small, clear creek like the one under consideration. Unless much precaution is taken in making direct observations, the proportions of species and individuals seen will be very different from those that actually exist for wary fish, like horned dace, hide, making the less shy fish seem to be the only ones present. Collections will not always give accurate information, for fish have different ways of responding to the presence of a net. Some go at once into the mud and beneath stones, and are easily missed, and the collection may contain only individuals that seek to escape by swimming. Often under very favorable conditions for collecting have I failed to get a single representative of a species which I knew, through observation, was present in the place where collecting was done. To obtain correct conclusions, therefore, concerning habitat preferences on the part of a species of fish, it seems necessary to get an abundance of data by every possible method during many seasons and obtained at all times of the day and year. These data for Campus creek are not yet at hand, so this paper will not attempt to set forth habitat preferences, but will deal with some of the more obvious environmental factors affecting the distribution of fish in Campus creek, which are: barriers, current, fish food, water temperature, and shore vegetation.

Barriers. Like most of the creeks about Charleston, there is a long stretch of shoal just above the mouth of Campus creek. This has a sandy bed with many ripple marks, and is usually dry in late summer and early fall, while the part of the stream above this area persists in its usual condition. This

forms an obstacle to fish when they are trying to come up the stream in the spring, except when the water is unusually high, and at such times fish are noticeably more numerous in the creek. Barriers in the form of leaf dams exist. There are accumulations of dead leaves against fallen limbs, brush, tree roots, fences, and the like, that are in the water. These dams often change the surface of the stream a foot or more in elevation, and fish can not get by them except at times of freshet. A little fall, about a foot in height in a piece of narrows, has been an obstacle to migrating fish in Campus creek during the last three springs; and it was interesting to watch them attempting to leap over the fall and to swim up it. Last year this fall seemed a perfect barrier till about the middle of April, when a period of high water obliterated it temporarily. After this time, stone rollers in large numbers were found nesting in the part of the stream above the fall, while prior to it they were only abundant and found spawning below it.

The Current. The direct effect of this on fish distribution in Campus creek has not been definitely made out. All the common species in the creek certainly prefer the deeper and quieter waters for permanent abodes, but many individuals come to the shoals from the pools at night and rest on the bottom where the water is swift. From observations made with a bicycle lamp in some of the streams about Charleston, including Campus creek, it appears that shoals constitute the chief nocturnal habitats for stream fish; the pools seem almost deserted at that time, and those shoals with rapidly moving water seem to be preferred, but more data are needed on this point. Stone rollers, with some exceptions, and also horned dace, go to the rapid and shallow water areas for spawning, usually just above the patches of riffles at the lower ends of pools. Male stone rollers, by pulling away the small stones of gravel bottoms, in the situations described, make little pits in which the females lay the eggs. These were very noticeable above many pieces of riffles in Campus creek last year, and these fish were seen working here from the last of March till after the middle of May. Some fish were found spawning

in very swift water of shallow riffles, where their bodies were out of water much of the time while working at the gravel. The only undoubted horned dace nest found in Campus creek was located in one of the tributaries of the stream in a narrow, shallow piece of swift water; but a number have been found in other streams in the region and all were located in a good current. Some silver-mouthed minnows were found spawning upon a sandy shoal where there was a moderate current last spring. The shoal with swift water seems to be least frequented by fish of all habitats in Campus creek except at night and by certain species at the spawning time. Its main function for fish appears to be that of a general highway connecting their diurnal dwelling places, the pools and deep narrows.

The current also has an indirect effect upon the distribution of fish by changing the bottom topography; for example, I noticed this winter that there is a broad shoal where a deep pool existed last fall; and in another place, where there was an extensive area of riffles used by stone rollers for nesting purposes last spring, there is now a deep pool. These changes will necessitate biotic changes involving fish as well as other organisms; and an opportunity will thus be afforded to observe directly the succession of forms inhabiting a particular part of the stream due to a change of environmental conditions. After a hard rain last April, the swift water completely denuded an area of gravel, which formed a piece of riffles used by many stone rollers for nesting purposes, and left in its place a shallow area a few inches deep, having a hard, blue clay bottom with a few pot holes and scattered cobble stones. Fish were found using these objects as places of concealment. Thus in a few hours one type of habitat was transformed into another, and each had a fish fauna different as to the species present and the way they reacted to their surroundings.

Food. This is undoubtedly a strong factor in determining the distribution of fish in Campus creek. Diatoms, entomostracans, and Chironomus larvæ are the chief objects that I have found by dissecting many examples of the common species.

Stone rollers, blunt-nosed minnows, and black head minnows feed largely on soil rich in diatoms. Chironomus larvæ and entomostracans formed the bulk of the food found in silver mouthed minnows and the blue-spotted sunfish. Some chub suckers had fed entirely upon soil and diatoms, and others upon entomostracans and Chironomus larvæ. The horned dace examined had a miscellaneous lot of insect fragments in their intestines including Chironomus larvæ and terrestrial insects. By further studies of the food of the fish of Campus creek, it is hoped that the distribution of the organisms used as food can be correlated with that of the species of fish that feed upon them.

TEMPERATURE. This effects the distribution of the fish in the stream indirectly and probably directly, but I have failed as yet to find any marked relation between temperature of water and fish distribution. They have been seen both active and inactive in winter when the water was near the freezing point. The largest number of fish ever seen by me in Campus creek was on January 28, 1906, when the water temperature was 6 degrees centigrade.

Some stone rollers taken at this time had their intestines filled with soil and diatoms. One winter I gave particular attention to a lot of fish that were remaining over winter in a pool in one of the tributaries of Campus creek, and I could see no relation between their behavior and the water temperature.

SHORE VEGETATION. As above stated, a grassy bank borders the stream almost everywhere, and this in many places overhangs the water due to the mat of soil and roots at its top edge, which resists erosion more than the portion below it. Under this shelf, fish and other aquatic animals like snails and various insects find a place of seclusion. From observations made on Campus creek it appears that fish are more often found where overhanging banks are present than at other places. Roots of trees also hold on to the soil, and often produce large overhanging banks; and where the roots are submerged, a habitat of a peculiar type is produced, for among them there is an intricate series of cavities in which fish often stay. The leaves

forming leaf dams and accumulations on the bottoms of pools, in which fish often conceal themselves, are contributed largely by the trees along the shore.

President Forbes appointed the following committee on nominations suggesting that, if possible, it report the first thing Saturday morning:

C. W. Andrews, E. J. Townsend, W. S. Bayley, F. C. Baker, E. N. Transeau.

Frank DeWolf announced that the apparatus in use at the newly established Mine Rescue Station would be on exhibition any time during the meeting.

T. W. Galloway reported for the membership committee the approval of an additional list of nominations and these nominations were voted in.

J. G. Coulter gave notice of a motion intended for presentation on Saturday.

The meeting adjourned at 5 P. M.

Evening.

8:10. John M. Coulter called the meeting to order in the gymnasium of the Woman's Building.

President Edmund J. James, in behalf of the University of Illinois, gave an address of welcome.

Mr. Coulter replied in behalf of the Academy: "I am happy to respond to this cordial welcome. No place could be more fitting for our meeting that at an institution which is the climax of the educational work of the State. This organization represents the cooperation among the scientific men of the State, and as an organization greatly appreciates the work of this university. We shall be stimulated by our meeting here. We shall now have the pleasure of listening to the presidential address which is the immediate reason for my presiding tonight.

The presidential address was then delivered by Stephen A. Forbes as follows:

RELATIONS OF THE ILLINOIS ACADEMY OF SCIENCE TO THE STATE.

The Illinois Academy is meeting this year at what we may now truly call a great state university, with its thoroughly organized and well-equipped departments of instruction and investigation in science both pure and applied; the home also of other organized public agencies for scientific work not immediately connected with instruction,—the Geological Survey, the Agricultural Experiment Station, the State Water Survey, the Engineering Experiment Station, the State Entomologist's office, the State Laboratory of Natural History, and the Soil Survey of the State; and we know that there are other active organizations elsewhere in Illinois of equal interest to us with those about us here,—the State Museum, the Field Museum, the Chicago Academy of Sciences, the great universities in and about Chicago, and the active scientific departments of the several colleges of the state, and of our five state normal schools.

Under these conditions we may reasonably ask ourselves the question: What is the place and proper work of this Academy in the midst of all this great array of established agencies for the scientific work of the State? What elements of scientific activity still remain in Illinois unorganized, or imperfectly organized, which can be brought together in a state society for their improvement in efficiency? What service may we possibly do to institutions and movements already in existence, by establishing useful bonds of affiliation and practicable systems of cooperation among them? What may we do to strengthen them? to supplement their work at any point by our own undertakings? to make them more immediately and more widely useful to the people of the state?

The earlier state scientific societies, in other states, had, in their beginning, a comparatively open field. They originated many movements and nourished the germs of many institutions which we now find permanently organized and in full operation here. We can not imitate them, consequently, even if we would, but must adjust ourselves independently to our own environment. Now, after two years of active operation, and with a membership list which insures us opportunity and promises us power, this seems a suitable time to start some fundamental inquiries as to our ends and purposes, and to begin the earnest discussion of practical answers to them.

Although I hold today a place of temporary advantage, and might assume to speak to some extent at least in the name of the society itself which has chosen me as its president for the year, I wish to disclaim any such privilege, and shall merely undertake to express my personal views from my own standpoint.

Our most immediate duty, as it seems to me, is to our otherwise unattached, active membership—to the private student, the isolated investigator, the occasional scientific worker in an unscientific environment, to whom we may, through our organization and our meetings, bring helpful acquaintanceship, appreciation, stimulus, and aid. Next we especially owe opportunity and elementary inspiration to the young—to the beginner, who may find in our meetings and in his own first paper on our program a not too difficult first step in a career which may lead him no one knows how far or how high. And then we owe to all of us, young and old, beginner and veteran, attached and unattached, an opportunity to know each other, and to learn something of each other's interests and accomplishments, and a look, at least, now and then, over some easy place in the wall of division between specialties and departments,—a chance to hear and to see the best and the latest thing in some other field than the one which we know best. And out of all this will come good fellowship and a broader knowledge, and not infrequently a reflected light on some problem of our own, involved in darkness hitherto, which no direct

light could penetrate; and best of all, there will sometimes come a chance and a disposition to get together, ignoring division lines, on some joint cooperative enterprise too large and too complex to lie wholly within the field of any one or any class of us, and likely otherwise to be ignored or imperfectly provided for.

The State Academy of Science may, like any other state society, do its part towards making the state interesting to its own people, and especially to those who are newcomers within its borders. In each of our great universities, and in many of our colleges and scientific institutions, there is an almost continuous stream of newcomers, some to take new places, others to replace those who are going away. Most of these, as a rule, come to us from other states, and some from foreign countries. They are often well prepared to make important contributions to our civic and our public life—to our scientific and industrial progress—but are sometimes little disposed on their arrival to go outside their special spheres of interest. They may even live among us, and yet not be of us, for years, concerning themselves but little with the state or its people except as their duties bring them into necessary contact with us,—a situation unfortunate for us and doubly so for them. Often their training and learning, their special abilities, their different standards, their tastes acquired elsewhere, make them precisely fitted to do some needed thing for us which we are not likely to do ourselves, and which does not get done because nothing is done to effect a real transfer of their allegiance. The very loyalty of their tempers, which would make them invaluable to Illinois if they were really to become identified with its interests, leaves them cold to us and makes them useless here for any general purpose, because it holds them still to other interests and places which they have left behind. Their own lives are more barren and lonely than they might be, and their stay with us perhaps is short, because they take no sufficient root in our soil. An acclimatization society is needed to adjust them fully to their new environment; and such a society the State Academy should actually be.

The Academy may do a great service also to our own people, by helping to increase their interest in their native state by increasing their knowledge of it, and by giving them new opportunities to contribute to its welfare. Loyalty is an emotion based on personal knowledge, on personal experience, and especially on personal service. The more we know of this great, rich, powerful, prosperous, and progressive commonwealth; the more definitely we can realize the conditions out of which, and the processes by which, it has come to its present high estate: the more justly we can estimate the energies working in its bosom for the future welfare of its people; and especially the more confidently we can be permitted to feel that we have personally contributed something, however little, but still our best, to its progress and its happiness,—the more devoted will be our attachment to it, and the greater, consequently, will be our future service. It is the one greatest and best function of this State Academy to make the State of Illinois known to itself.

Loyalty and state pride are, however, by-products of a scientific society, to which many other societies of various kind and aim may contribute equally. Our own *special* mission is the aid and advancement of scientific research and the popularization and propagation of its results. For both these aims we need to bring the scientific men and the people of the state into closer and more frequent contact, in ways and under conditions to increase the popular respect for scientific work and the popular appreciation of its outcome, and also to interest our scientific men more strongly in problems affecting the general welfare. Especially we must remind the absorbed investigator that it is the part of science to understand its own environment, and to adapt itself thereto; that science is not, and perhaps can never be, wholly self-sustaining, especially in a democracy; and that without the broadest possible basis in popular gratitude and regard, the progress of science will be needlessly retarded and its development delayed. The happy thought of an annual symposium on some subject of primary importance and strong human interest is, I think, a great help

to these ends; and the discussion of the relations of the pure and applied sciences which our representatives for the year are to hold tomorrow forenoon is an excellent example of what I now have in mind. I hope that we may make even more than we have done of the symposium idea; and that we may select and assign our topics for discussion with great care and early in the year, that those chosen for this service may have ample time for the careful preparation which its importance demands.

I have spoken of the Academy on the one hand, and the people of the state as its constituents on the other; but from another point of view we are the representatives of the people and the immediate constituents of the scientific institutions of the state. We have in our membership not only the managers and the workers of these institutions, but a select group of citizens also, especially concerned in their work and especially intelligent with respect to it. Our geologists and geographers and certain of our biologists follow the operations and study the reports of the Geological Survey with an interest at least as great as that of the miners and quarrymen, the clay men and the oil promoters, for whose benefit its work is primarily done. The Soil Survey concerns not only the farmer, but the botanist and the zoological ecologist as well, and so of most of these departments of state activity. Although not established, as a rule, for our purposes, but with some economic end in view, each of them is of great interest and importance to one or the other group of us, and virtually all of them contribute materials highly valuable to those of us responsible for scientific teaching of whatever grade. Our interest in the work of these institutions is mainly scientific, while that of their other constituents is merely economic, and it goes almost without saying that we may have, and ought to have, a strong and helpful influence over it. There is nothing that is more needed by any active department of economic work than an intelligent, watchful, and appreciative scientific constituency. Its more immediate beneficiaries and supporters are commonly in a position to criticise only its more practical results, and can usually know but little of the scientific wisdom

and validity of the methods by which these results are reached. They may even embarass, discourage, and delay a correctly managed undertaking, by an impatient demand for a practical outcome before any such outcome is fairly attainable. They may overvalue and overpraise the empiric at the expense of the scientist, and may greatly overstimate a relatively easy and simple piece of work, which yields an immediate and important economic product, as compared with a difficult and complicated one whose progress is necessarily slow. A sufficient body of intelligent, conscientious, and disinterested critics of the scientific work of the state, such as I hope this Academy may always be able and ready to supply, would help greatly to correct the distorted perspective in which an economic science is commonly seen by the economic citizen. Furthermore, the membership of this Academy is the natural and immediate constituency and support of such *purely scientific* work as the state, or any other public agency, may choose to foster or initiate. With its general outlook over the whole field of human welfare and scientific activity, it ought to be in a position to suggest or to set on foot new work in lines neglected hitherto. This view of the legitimate and possible relations of the Academy to public scientific work seems to have been foreshadowed, whether consciously or unconsciously I do not know, by the description and resume of that work contributed by our last year's symposium, and contained in our Transactions for 1909. I commend this review to your attention as worthy of careful study. I would like to see, and am indeed ready to advise, the appointment of annual committees of this Academy on scientific progress within the state, to present reports which, published in our Transactions, will form a continuous and, in course of time, an invaluable record of the history of scientific enterprise in Illinois.

These are delicate and important functions which I am proposing to you, and all this implies, as you will see at once, that the State Academy is really to succeed and to continue to succeed; that it is to attract and to hold in its membership the best, the most experienced, and the most public-spirited scien-

tific men of the state; and that they are to enter into its work with interest and energy as worthy of their time and serious attention. I would, indeed, *make* this work worthy of the best thought and service of the best men among us. If we do that, their thought and service, I am sure, will be forthcoming; and if we do not, we shall shortly find that those whose presence and assistance we most need are conspicuous by their absence from our meetings. I must make, also, this assumption of continued success and of high-grade, disinterested service, in what I shall have next to say of the relations of the Academy to the State. If I shall seem to make this topic too prominent at this meeting, paying too little attention to other allied interests, I trust that you will accept my apologies in advance. There are many others far better qualified than I to deal with other aspects and relations of our work and influence, but if there is any such topic on which I may be thought somewhat competent to speak it is this of our relations to the State, in whose scientific service I have really spent, I suppose, a longer time than most of us have lived.

In all that we may do or propose with respect to general state work, we should of course be sure that we are assisting and strengthening existing active agencies, and not weakening them or supplanting them. We should, in other words, hold and develop what we have, and add to it what and where we can. For this reason any general plan for state-wide work which may be presented to the Academy should be carefully scrutinized and reported upon by a special, disinterested committee, which should act conjointly with any state agency operating in the same field. This is essentially the course taken by us with respect to a proposition for an ecological survey of the state made to the Academy by some of our ecological members at its Decatur meeting in 1908. As the survey proposed came within the field of operations of the State Laboratory of Natural History, charged by law with a natural history survey of the state, the forces of the Academy were united with those of the State Laboratory by means of a committee report approved by the Laboratory management and accepted by the

Academy; and a standing committee was appointed, with the Director of the Laboratory at its head, to organize and conduct this work. The principal, actual outcome of this experiment—for an experiment, of course, it is—has thus far been a review and endorsement, by this committee, of the State Laboratory plans and operations, and a common understanding among the active investigators in this field as to their respective subjects, fields of operation, and interrelations, arrived at with a view to the coordination of all parts of this work and a fairly uniform and symmetrical final product. The publication of several papers on the ecology of the state by members of the committee has been provided for by the State Laboratory, and these papers are appearing as articles in its Bulletin. Both state and individual work have thus been stimulated and somewhat expanded, so far without increase of expense, and with notable addition to the scientific and educational value of their product.

Possibly other plans of cooperative aid to other state agencies might be profitably set on foot by committees of conference appointed for the purpose. Others of our members may be so situated, so educated, so interested, and so experienced, that by coming together and by allying themselves with the Water Survey, the Geological Survey, the Soil Survey, or the State Museum of Natural History, they could at once give greater system, definiteness, and value to their own work, aid to each other, and important assistance to these organizations, either by the contribution of useful observations and material, by supplementary studies made along allied lines, by intensive local work and other continuation studies, beginning where the state work leaves off, or by adapting the products of special work to educational uses.

In order to insure the success of such cooperative plans, it is, of course, a prime necessity that thoroughly disinterested motives should prevail, and that the advancement of science in the interest of the state should be the touchstone by which all plans and persons shall be judged. I fully believe that we can trust each other confidently in these matters, and that the way

is open on all sides to various forms of helpful organized activity, which ought in a few years, if properly directed, to give a new aspect to the status of science in Illinois.

There are, however, certain limiting and controlling conditions to joint enterprises of this description, which must not be overlooked or ignored. Agents of the state, placed in charge of work provided for at public expense because of its importance to the state at large, can neither divide their duties with others nor share their responsibilities except as required or permitted by law. A considerable administrative discretion is commonly vested in them, however, within which any such adjustments as I have had in mind might readily be made. They can thus often assist materially an independent society or even a private citizen, and can receive material assistance from such sources with real profit to their enterprises, and an enlargement of their usefulness. Most of them are, in fact, really eager for such mutually profitable connections, and often take great pains to establish them, and it is, of course, good public policy to secure for any public enterprise all the really competent volunteer aid possible, in order that its results may be most quickly reached at a minimum cost to the public as a whole.

On the other hand, an academy of science is not a compact organization capable of carrying forward long, complicated, laborious, and expensive undertakings, requiring for their accomplishment the continuous cooperation of a group of men working, each in his place, to a common end. Such undertakings belong to established institutions and not to volunteer societies. Consequently we should not seek to do the work which the State has undertaken, or is likely to undertake, on its own account and at public expense. *Per contra,* the State should not tax its people for what any of them are willing to do for their own purposes, and which they can do well enough and quickly enough to serve also the public interests concerned. It may, however, provide agencies of coordination, may supplement private work, especially where extensive, complicated, and expensive operations are required, and may give such assistance to that work as is warranted by its general

value as an aid to education, as a foundation for more immediately productive operations, and as helping to create a background of appreciation for the work of the state agencies themselves. It is in this sense that it seems perfectly proper that the State of Illinois should provide at its own expense, as so many other states have done, for the publication of the Transactions of its State Academy of Science. Whatever tends to stimulate a general activity in scientific work throughout the state and to increase the public interest in it; whatever makes available for the general public the product of valuable unpaid services of private citizens; whatever helps to familiarize our people with the true objects and methods and the outcome of scientific investigation, will have consequences, immediate and remote, so important to the public welfare, material, intellectual, and social, that the petty sums needed for the publication of our papers will certainly, as it seems to me, be invested at an enormous rate of final profit.

It is especially in this period of an emotional reaction against science and the scientific method, when whole sections and sects of our people seem fairly rushing down a steep place into the sea of fantastical speculation and conjecture, that we need in every community the sane, cool, impartial spirit of science, at work along all lines of intellectual activity. It is not an empty reproach which Professor John Dewey, of Columbia University, brings against those of us who are science teachers, in his recent address as chairman of the educational section of the American Association for the Advancement of Science, when he speaks of the slight extent to which the teaching of science has hitherto protected the so-called educated public against the recrudescence of all sorts of occultism, superstition, and silliness. "The future of our civilization," he continues, "depends upon the widening spread and deepening hold of the scientific habit of mind; and the problem of problems in our education is, therefore, to discover how to mature and make effective this scientific habit. Scientific method is not just a method which it has been found profitable to pursue in this or that abstruse subject for purely technical reasons. It represents the only method of

thinking that has proved fruitful in any subject—that is what we mean when we call it scientific. It is not a peculiar development of thinking for highly specialized ends; it *is* thinking, so far as thought has become conscious of its proper ends and of the equipment indispensable for success in their pursuit."

Our relations to the progress of scientific investigation within the state, important as they may be, are really overshadowed, as it seems to me, by those which we bear, or ought to bear, to the progress and improvement of scientific education. Topics of this description are most commonly dealt with by bodies too narrowly limited in their membership to see the subject equally well in all its bearings, and their conclusions are hence likely to be partial and tentative only. The Academy has, however, within its active membership, scientific investigators of various sorts, university and college professors, normal and high school teachers of the several sciences, and a considerable body of picked, but fairly representative patrons and supporters of all kinds of schools; and I can think of no organization better constituted to discuss our special educational problems in a broad, intelligent, and effective way. We shall have tomorrow, I hope, a favorable example of such a discussion in the contributions of our symposium; and to the participants in that discussion I am pleased to be able to leave the illustration and development of some of the ideas which I have here tried to present. If the outcome shall be the appointment of a carefully selected, composite committee on scientific education in Illinois, and if that committee shall do its best to present to the Academy next year a well-grounded, well-rounded discussion of the subject, with recommendations for our procedure, I think that we shall all have reason to congratulate ourselves that this Academy exists; and if, in addition, the Academy shall be able to exert continuously upon scientific investigation, upon education, and upon the life of the people, something of the unifying, organizing, rationalizing, and corrective but generally stimulating and educative influence which I have here described as its reasonable function, I am sure that it will presently come

to be regarded as one of the most powerful of agencies for the advancement of science and the promotion of human welfare in this State of Illinois.

The chairman then introduced T. C. Chamberlin who gave the following address.

THE CHINESE PROBLEM.

When I replied affirmatively to the Secretary's request that I give some account of my recent studies in the East it was with the thought that my remarks would fall into a much less important place on the program. I should in any case have been embarrassed to select from the many things which ought to fall under observation on such a trip, but I am especially embarrassed in choosing what may be appropriate to a talk following the scholarly address just delivered by the President of the Academy. My trip to the Orient had an educational rather than a scientific purpose, but the educational and the scientific are intimately related, and a study of educational development in the Orient is scarcely less than a scientific study in itself, since in its broader aspects it embraces everything that enters into the welfare of the people.

The education of the Chinese people, to which I shall confine myself, is essentially a problem of transition from an old adjustment to a new adjustment. What we see today are but the early stages of the transition from an adaptation to a past set of conditions to an adaptation to a coming set of conditions. The past evolution of China has been controlled by conditions of isolation; the coming evolution is to be controlled by contact with the rest of the world. The past evolution illustrates the influence of the factor of isolation in evolution, a factor much discussed recently by Jordan and others. The evolution of a civilization is indeed broader than the evolution of a biologic species, for it is at once a physical, a biological

a mental and a moral evolution, but it carries the same philosophic import.

I can only point out a few of the suggestive features of Chinese evolution under her past conditions of isolation; and first among these, the physical setting of the evolution. Until the sea became a highway, the Chinese were measurably shut off from the rest of the world; on the west by lofty mountain ranges, the Thibetan plateau, and the great deserts; on the north measurably by the Mongolian plateau; on the east and southeast by the sea; on the south partially by lofty parallel ridges and deep valleys. The Chinese seem always to have been a stronger people than their neighbors on the south, and the tendency in that quarter has been for the Chinese to flow out rather than suffer incursion. On the north, where the natural barriers were weakest, the great wall of China was added as a supplementary barrier. This implies that isolation was a condition earnestly desired by the Chinese people. They preferred to work out their destiny alone. They therefore at great labor erected the most remarkable of artificial barriers, and yet a barrier whose efficiency was confined rather to protection against marauders, hostile bands, and turbulent neighbors than against well equipped armies. It is significant that the Chinese chose thus to guard themselves by a passive defense rather than go out aggressively to attack and destroy their enemies or take possession of their lands. They thus demonstrated that they long have been what they still are, conspicuously a peaceful people, non-aggressive and non-belligerent by preference. Under such natural and artificial isolation their remarkable development and their former adjustments took place.

The natural features that constituted these barriers of isolation had not only their general effect on the Chinese people, but their influence on such special factors as the climate and the soil, and these in turn gave shape to the Chinese industries and determined many of the conditions of life. The high interior on the one side and the sea on the other formed and still form a working climatic couplet.. In the winter the coldness

of the mountains and plateaus of the interior give density to the air and cause it to flow down the slopes eastward and southward toward the sea. As it descends it becomes absorbent and hence the winters are dry and cool. In the summer, the interior air is heated and, pressed by the cooler air from the sea, becomes ascensive. As the moist air flowing inland from the sea rises, it becomes precipitant, and hence the summers are warm and moist. In north China notably it is the July and August rains that are the foster parents of the crops.

The moisture borne inland by the ascensive summer winds and precipitated on the slopes of the interior, on the barrier mountains, and on the bordering plateaus, bears back from them to the lowlands a constant burden of new soil material, a means of natural fertilization. By this fresh material the alluvial plains are built up and built out seaward, and their fertility is naturally renewed wherever such accessions take place. In the northern tracts there is added an annual film of dust from the deserts. Thus even the deserts make some compensation for their barrenness.

But the extraordinary preservation of the fertility of China is due mainly to the unusual care and intelligence of the Chinese people in the management of their soils and the handling of their plants. The plants they cultivate may almost be said to be treated individually, as animals are by other peoples. Seed is rarely sown broadcast. Even cereals are planted in hills or rows. Fertilizers also are often planted with the seed or applied to the hills tho often also spread broadcast. The fields are carefully prepared and scrupulously tilled. Interestingly enough, plant reciprocities have been discovered, no doubt by pure empiricism and without even now knowing the reasons that lie back of the observed effects. One often sees rows or hills of wheat alternating with beans, mustard alternating with peas, and various other alternations of legumes with cereals and other plants, thus securing the simultaneous cooperation of plants well fitted to one another. We seek the mutual good offices of plants by rotation, but the Chinese go a step further and secure this by inter-planting. The results

obtained astonish one acquainted simply with what is usually seen on Wisconsin or Illinois farms. The cereal crops, even when raised wholly by themselves, reminded me of those grown on the virgin soils of our interior plains in the early days. Fields of grain of great luxuriance were common, and fields of mustard, a crop much raised in central and western China, often overtopped one with plants 8 or 10 feet high. These results no doubt follow from the long and patient trials of the Chinese under the stimulus of their critical dependence upon the fruitfulness of their crops to feed their vast multitudes. It is their solution of the best relations of plant to man and man to plant.

To better adjust themselves to the severe demands of a dense population, the Chinese have resorted to a suggestive biological selection; the choice of the fittest, as they see fitness; the selection of man at the expense of the domestic animals. Plants are obvious necessities, but, especially in the central and southern districts, animals other than man are reduced to a minimum rather than multiplied to serve as convertors or burden-bearers, as is our practice. Biological evolution in China has thus tended toward a bilateral form, man and plants. The animal intermediaries of nature have fallen in some districts almost to a negligible element. Instead of one man and a horse to help him, it is three men.

But the barriers which had isolated China for thousands of years have been broken down, and the question now arises, what will be the nature of the new adjustment, what form will the new evolution take. We may pertinently ask ourselves, have these barriers been broken down because westerners wish to carry to China the benefits of their best civilization, or because westerners wish to exploit the people, and the resources of China. Or, if motives have been mixed, what is their ratio? Must China now adjust herself to a militant world where force dominates, or need she merely become receptive toward the best that civilization offers? Is it the soldier or science that is to creep in through the gaps in her broken barriers? No

doubt the historical answer will be, both the soldier and science. It is clear that two quite diverse phases of western civilization are struggling for dominance in the readjustment now in progress, that of aggression and appropriation by force, and that of benevolence and broad humanity.

It may be idle to preach the relative virtues of these, but the western world may well sit down and compute the respective costs to itself. China has some four hundred million inhabitants. I was skeptical about these large numbers when I went to China and cannot now say I am wholly convinced of their accuracy, but taxes are said to be apportioned to the provinces and other districts subject to levy on the basis of the number of inhabitants recorded. The local temptation is, therefore, toward scant registration rather than an exaggeration of the census, so much so that penalties are imposed to correct this. It is hence cogently urged that the census returns give less rather than more than the real number of the people. At any rate, they are a very numerous people, a people of declared character and of persistent traits. It is therefore a matter of no small moment to foresee what new traits they will take on as they readjust themselves to the new situation. This is none the less important to the rest of the world because the essence of the new adaptation is *adjustment to the rest of the world*. It is the outside world that has broken down the barriers of isolation and forced the issue. The outside world must, therefore, stand by the consequences of its own forceful intrusions, and it does well to consider what those consequences will be—to weigh well its own part, in shaping them, at least from this time on.

The Chinese of the south, acclimated for some thousands of years to sub-tropical conditions, have physical and mental characteristics which I cannot better express in a word—tho inadequate—than to call them feminate—I do not say effeminate—men of small bones, small hands, small physique generally, with a touch of the feminine cast; bright, active and enduring, with some predisposition to restiveness and migration, but on the whole non-aggressive as compared with Europeans.

In the middle and high latitudes, the Chinese are larger, stronger, bigger-boned, more masculine, more individualized, perhaps slower and seemingly duller, but more independent and more aggressive, notably so as they merge into the co-national and kindred peoples who dwell on the Manchurian plains and on the Mongolian plateaus. At Hankow, a metropolis of the south, you many note a policeman—one of the signs of the new order of things—standing on the side of the street and looking apologetic; in Mukden, the policeman stands in the center of the street with the bearing of a soldier, and cart and rickshaw and coach alike pass scrupulously on the appointed side. There was no temptation to test it, but the policeman's bearing suggested that you might easily look down the barrel of a revolver if you insisted on taking the street at your own sweet will. Chinese immigrants to America are almost wholly from the south and center of China, where the ancient tendency to outflow is most marked. There are few immigrants from the more sturdy races of the north, practically none from the open fields of Manchuria and Mongolia, or from the adjacent provinces which are overflowing into these uncrowded tracts.

Now we may well ask ourselves, whether, having thrown down the barriers and forced these peoples to adjust themselves to contact and intercourse with ourselves and the rest of the world, the adjustment shall be on the lines of peace, equity and the truer forms of cooperation, attended by all the higher qualities of which the western world boasts, not the least of which is its scientific spirit and method, or shall it be on the lines of war and aggression in which the west, notably the European west, is past master. In a world, is the readjustment to be a fitting together for peace, or a fitting out for war; a fitting together for mutually profitable intercourse or a fitting out for inequitable trade and the fierce rivalry of grab.

If we continue to elect the latter alternative what may be the issue of a forced education of four hundred million people in the art of war and the spirit of aggression? In traveling from the metropolis of the southern interior toward the capi-

tal, it was our fortune to take a train on which the young son of a high official of the general government also traveled. For the two days we journeyed together, at every important station on the line a company of soldiers paid their military salutations to the representative of the official, and incidentally thus revealed to the foreign student of education what sort of education is in progress in China. I may have misinterpreted, but the military display did not seem so much a matter of obligation, since only the young son of an official was journeying by, as a good chance to drill the soldiers, to create a public impression, and to foster a military spirit among the people. To a civilian the troops seemed well drilled and well equipped with modern weapons. They were uniformed, not in Chinese costume, but in western fashion, in boots, caps and khaki. Traveling later from Peking northeastward into Manchuria, in the complete absence of any special occasion, a squad of soldiers was found drawn up at practically every station, soldiers of good appearance and apparently well armed. These squads at the station seemed to be merely the natural response of the Chinese to the example of "guarding the railroad" set by the Russians and Japanese farther to the east and north in Manchuria, the natural Chinese response to the compulsory education forced upon them by their instructors. In hunting a salubrious site for a possible educational institution outside a populous city in the south, we ran into a sham battle of approved European type. In far west China, when we called to pay our respects to an official, we found a company of soldiers drilling in the court of the yamen. We saw military schools and military drill in the common schools. These are merely incidental evidences of one phase of the education that is going on in China.

Now let us compute a bit. If one person in every hundred —an approved European ratio, I believe—is kept in military service in a population of four hundred millions, with rotation to develop the reserves, and if an eye is kept open to working into the permanent service as much of the blood inherited from the soldiers of Gengis Khan and Kublai Khan as practi-

cable, what will be the *reciprocal effects* on western military requirements and what will be the inevitable financial burden, some touches of which Europe is even now feeling on her own account. We may leave to the Orientals to count their own costs, for if we force them we perhaps do not care, but what will it cost the western peoples to be ever ready to meet the possible aggressions of four million soldiers inspirited and drilled to fight for their nation's life, backed by proportionate reserves and supported by well developed resources. What will it cost Europe if the four hundred millions of China are forced to acquire the skill and the spirit of the forty millions of Japan?

I think there is no necessary "yellow peril" now, but if a "yellow peril" is foreshadowed, of whose creation is it to be? If China is to enter the lists of aggressive military powers, is it of her own free choice, or is it under compulsion? If under compulsion, whose compulsion? If the result be expensive, who ought to foot the bills? Who will ultimately be likely to foot the bills?

Fortunately China loves peace; China has given historic demonstration of her love of peace as few peoples have ever done. Is not this love of peace an asset worth cultivation by western nations? It is not indeed worth importing and cultivating on western soil?

China desires scientific education. Just now she is more anxious for the results than the method and the spirit. She would like to put her four hundred millions into the western type of efficiency which Japan has given to her forty millions. But still China prefers peace. And the radical educational question of the hour is this: May she have the scientific education of peace which she prefers or must she have first a scientific education for war? May she secure peace by peaceableness or only through prowess in battle?

In the past the Chinese have placed the scholar at the top of the social scale and the soldier at the bottom. Will the western world permit this scale to stand and adopt it for themselves or will they force its reversal? Will the West do what

is best for the East and for the West alike? Will the West join in promoting the spirit and method of science, in the spirit and method of peace? In a word, will the West be eminently wise or stupendously foolish?

The Chairman then announced that a reception would be given by the Illinois Chapter of Sigma Xi in the parlors of Woman's Hall and the audience repaired thither.

SESSION OF SATURDAY, FEBRUARY 19.

MORNING.

The meeting was called to order by President Forbes at 9:15. T. W. Galloway proposed an additional list of candidates for membership and upon motion of E. J. Townsend the persons named were elected. After some announcements the following report of the committee on Ecological Survey was presented by H. A. Gleason.

REPORT OF COMMITTEE ON AN ECOLOGICAL SURVEY.

Your committee on an ecological survey has practically resolved itself into a body of associate workers, engaged, each on his own line, in a study of the ecology of the situations open to him, the various lines of work being conducted, however, with reference to subsequent unification and amalgamation as parts of a comprehensive scheme of work for the entire state. The committee has had two meetings, one held June 18, 1909, at Havana, on the Illinois river, the site of the operations of the Illinois Biological Station, and the other at Urbana last evening, for the purpose of formulating this report. At the Havana meeting the plans and lines of work of the Biological Station, and those of individual members, were fully presented, discussed, and approved. A brief outline of the work of the group for the year will be of interest to the Academy.

Virtually all the work of the State Laboratory of Natural

History and of the State Entomologist's office is ecological in the broader sense, having to do with the relations of animals to their environment; but much of this work, directed to economic ends, is too miscellaneous to be taken into present account as a contribution to a systematic survey of the ecology of the state.

Five special lines of work, however, fall strictly within this field; namely, the aquatic work of the Biological Station at Havana; statistical work on the numbers and local distribution of Illinois birds; the work of the forestry survey of the state; a systematic survey of the mammals of Champaign county, a report on which is now nearly ready for the press; and a study, by the State Entomologist's office, of the local distribution, peculiarities of food, and other relations to nature, of the various species of *Lachnosterna*, or May-beetles, the parent insects of the white-grubs.

The aquatic work of the Biological Station was recommenced July 1, with Mr. R. E. Richardson in charge as resident naturalist. An important part of the season's work has been the making of a series of plankton collections comparable with those made in the same places during the five-year period 1894-1899. It is the object of these collections to bring into quantitative comparison the present productivity of the waters of the river and connected lakes with that of the time preceding the opening of the drainage canal from Lake Michigan into the Illinois river. Large collections have also been made, necessary to a study of the food of various kinds of fishes in various parts of the area under command from the Biological Station, and data have been obtained for a comparison of two strongly contrasting overflow lakes in the vicinity—Thompson's lake, north of Havana, and Matanzas lake, southwest of it.

Field work on the statistics of ornithology was carried on during June, July, and August, in a way to verify and extend our knowledge of the resident midsummer bird population of the state in northern, central, and southern Illinois respectively. The work was done in a way to enable us to eliminate

differences due to an advance of the season merely, and to distinguish clearly those due to latitude, and to climate corresponding.

The forestry survey work has been resumed under an arrangement with the United States Forest Service, which insures its completion within the next two years. The State Laboratory of Natural History and the U. S. Department of Agriculture share equally in the expenses of operation. Two assistants of the Survey and one from the Entomologist's office are now in the field in southern Illinois.

Collections of Lachnosternas were made last spring by entomological assistants in all parts of the state from various situations, and on a selected list of food plants. Some sixty thousand specimens have this year been determined as to species, and a tabulation of their ecological data is now in progress.

A report on the mammals of Champaign county, prepared by F. E. Wood, is based on a large amount of exact and careful field observation extending over three years. Ecological data of every description are included in this report.

It was hoped that we might be able to begin, as a regular part of the program of the biological survey, a systematic analysis of the state of Illinois with reference to habitats as a foundation for an ecological map, or series of maps, of the state, and the legislature was asked for a sufficient increase of State Laboratory appropriations to enable us to begin this work. No such increase was made, however, and the operations of the Laboratory are consequently limited, for the present two-year period, practically to lines already established.

Mr. Baker has made a survey of the Skokie Marsh region near Chicago, an area three miles long and about a mile wide. The results have been embodied in a paper in which the mollusks and associated plants and animals are listed and the habitats described. This paper, illustrated by a number of photographs of the several stations and several maps, is in course of publication in the Bulletin of the Illinois State

Laboratory of Natural History. Collections have also been secured and some studies made at Fox lake and Cedar lake, in Lake county.

Mr. Shelford has made some original observations, and a study of the literature, on the gross features of the Chicago region which influence the ecological distribution of animals, and has brought the results together in a base map of the Chicago area. He has conducted a study of the animal societies of twenty stations in the Illinois portion of the Chicago region, so selected as to represent the most important ecological features. These results, together with a detailed study of as many more stations in Indiana, a large part of which represent conditions which existed in Illinois before the building of the city of Chicago, are being brought together in a paper on the animal societies of the Chicago area, now nearing completion. This paper discusses the succession of pond and stream animals, and the succession of animals associated with the forest development.

One of the students working under Mr. Shelford's direction has begun a detailed study of the region from the Skokie Marsh to the Lake, in continuation of the work done by Mr. Baker. Another is making a study of some of the older sloughs inside one of the old lake beaches, and has followed one of these sloughs for nearly a year. A third is following throughout the year the fauna of a small plot which is a temporary pond in spring and low prairie in summer.

Mr. Hankinson is making an ecological study of the fishes of the streams about Charleston, ascertaining their feeding and breeding habitats, the character of the bottom, the depth of the water, and the speed of the current preferred for these purposes. He divides each stream into stations, and makes collections from each as often as possible at all seasons of the year, taking detailed notes of the depth and width of the water, the temperature of air and water, and of the vegetation and the species of vertebrates associated with fishes in these collections. A qualitative study of the food is made for each species, and correlated with the numbers of organisms

available at the time in a way to explain the habit preferences on the part of fishes. Special attention has been given to a small stream near the grounds of the Normal School, the product of which will be presented by Mr. Hankinson in a paper to be read at this meeting.

Mr. Transeau's work relates to the plant formations of the Charleston region, and to habitat and seasonal relations of the algae. Under the first of these heads he has made record of the vegetation of about thirty localities, in an attempt to get at the trend of succession. He has made some progress in the determination of the evaporation constants for several woodland types and topographical situations. He has made more than a hundred collections of algae representing all the habitats and all the seasons and about forty-five species of algae. In connection with this work some experiments have been made on the effect of a change of environment on the form of algae.

Mr. Gleason began, during the summer of 1909, preliminary work on the forest associations of Champaign county, with particular reference to their relation to the drainage systems. It is planned to push the investigation further during the spring and autumn of 1910, and to produce eventually a complete vegetation map of the county, showing the present and past distribution of every plant association, and accompanied by descriptions of the vegetation and its ecological relations. Since this work will be done chiefly in connection with the advanced classes in ecology in the University, it will probably require several years for its completion. Material is being slowly accumulated from the Mason Historical Library relative to the original distribution and structure of the various types of vegetation of the state.

The results of the field work on the sand dune vegetation of the state have been elaborated and are now ready for publication.

Mr. Adams has begun an inquiry into the sources of ecological data preliminary to a general treatment of the subject of Illinois as a biotic environment. He also made, for the State

Laboratory of Natural History, an ecological reconnaissance of the aquatic habitats of the Illinois river at Havana in comparison with those of the period before the opening of the Chicago drainage canal, some of the results of which studies will be presented in a paper to be read today.

The committee greatly desires the assistance of the Academy in two directions. First, we should have a larger number of local workers engaged, like most of us, in ecological studies within their own neighborhood; and, second, the State Laboratory of Natural History should have an increase of its appropriations sufficient to enable it to engage seriously in statewide studies of types of habitat, with a view to the construction of an ecological map of the state. It naturally falls also to the State Laboratory to prepare a synopsis of the various species of animals not sufficiently described in works available to the student, without which local work must be done imperfectly and under very serious disadvantages.

Respectfully submitted.

STEPHEN A. FORBES, Chairman.
T. L. HANKINSON,
VICTOR E. SHELFORD,
H. A. GLEASON,
E. N. TRANSEAU,
FRANK C. BAKER,
CHAS. C. ADAMS,

Urbana, Ill., Feb. 18, 1910.

T. W. Galloway.—"Mr. Chairman, I should like to ask whether your ecological committee has yet found itself able to do anything in the determination of the ecology of Illinois biologists themselves."

T. J. Burrill.—"I am glad to see that the committee has not only announced plans, but has made positive contribution in this work. The report shows how much work there is at our own doorstep in our immediate neighborhood."

Isabel Smith.—"In Morgan county we are trying to prepare

a complete report on the flora and especially the trees, and in a year or two we hope to be able to submit results."

T. J. Burrill.—"I wish we had a Miss Smith in every county."

J. A. Udden.—"I wish to make a suggestion and that is that it would, in my opinion, be a good idea if this survey might make itself more generally known by the use of existing publications. There are people in every county who would be interested."

Mr. Andrews.—"The committee on nominations is ready to report."

Mr. Forbes.—"We will hear the report of the committee."

Mr. Andrews.—"Your committee unanimously nominated the following as officers for the coming year."

For President, John M. Coulter, University of Chicago.
" Vice-President, R. O. Graham, Illinois Wesleyan University.
" Secretary, A. R. Crook, State Museum of Natural History.
" Treasurer, James C. Hessler, James Millikin University.
" Third Member of Publication Committee, H. H. Stoek, University of Illinois.
" Membership Committee, Fred L. Charles, University of Illinois, Chairman; Thos. L. Hankinson, Eastern Illinois State Normal; V. F. Shelford, University of Chicago; W. E. Tower, Englewood High School; Isabel Seymour Smith, Illinois College.

Mr. Burrill.—"I move that the Chairman of the committee on nominations be instructed to cast the ballot for the gentlemen named." Carried.

Mr. Andrews.—"The Chairman of the committee announces that he has cast the ballot for the names nominated. They are elected."

Mr. Forbes.—"Prof. Udden has a report for the committee on drill records."

J. A. Udden presented the following report:

REPORT OF THE COMMITTEE ON DEEP DRILLINGS.

The Committee on Deep Drillings can report progress in its work. Early in November last year circular letters asking for various data on wells in the state were mailed to the members of the Academy. Replies have been received from nearly all the recipients of these letters, and data of importance have been furnished by many of the correspondents.

The committee desires to express its high appreciation of the courtesies which have been extended to it by the members of the Academy and acknowledges with gratitude the aid which has been received.

J. A. Udden,
U. S. Grant,
Frank W. DeWolf.
Committee.

February 18, 1910.

President Forbes then announced the symposium which was presented by Cornelius Betten, Julius Stieglitz, J. F. Hayford, C. G. Hopkins and Worrallo Whitney as follows:

SYMPOSIUM

THE RELATION OF PURE AND APPLIED SCIENCE TO THE PROGRESS OF KNOWLEDGE AND OF PRACTICAL AFFAIRS.

1. The Relation of Pure and Applied Biology.

Cornelius Betten.

It may be well to call attention to the fact that the subject set for discussion makes distinctions which, if they are convenient, are after all largely fictitious. The contrast between pure and applied science, as generally conceived, is that implied in the statement of the subject, namely, that applied science has to do with the practical affairs of life, while to pure science

we indefinitely ascribe the progress of knowledge. This distinction means little or nothing to us. If history teaches us anything, it teaches that the advance of knowledge is the most practical affair in which we may engage. It shows us that scientific investigation which seems farthest removed from the life of the people today, may before long have tremendous bearing upon the welfare of our own species. It is, of course, for us individually to decide where we can most advantageously help the cause and train and broaden ourselves in the doing of it; by remaining close to what is today the vital practical application of science, or to venture into studies whose ultimate bearing upon human life can only be conjectured. To those of us who are in the work of education it becomes a pressing problem also to decide this question for those who come under our guidance. There are certain apparent dangers in the introduction of vocational work in non-technical education, and so guarded have we been against them that the general attitude is to admit only the minimum that is needed to enlist the interest of the student. At present however, it is becoming more common to admit the maximum that will not conflict with well established educational principles. It seems to be becoming more clear that the practical bearing of a subject is a real asset. We should understand, however, that the aloofness of science from common affairs is obviously a matter of degree, and time generally wipes out that difference or not infrequently inverts its terms. We may hope that our pure science, in the pursuit of it or in its direct results, may some day bring benefit to mankind, and we may at the same time fervently believe that the immediate relation of applied science to the needs of the human race does not vitiate its educative value to him who engages in it.

It is obviously not possible in the time here allotted to review with any degree of care the multitudinous ways in which the biological sciences are today affecting the progress of the race. At the risk of dealing only in what may be platitudes to this audience, I limit myself to some of the more general aspects of the question.

Any science evidently affects the progress of the race in three ways: it trains men in methods of thought and work, it furnishes a body of directly useful information, and it establishes a few general concepts that have great influence in determining men's approach to the problems of life.

In method the sciences are fundamentally the same, though they may differ in the stage of their development. Thus today biology is only entering that phase in which physics has for a long time been and into which chemistry has more recently entered, namely the stage of experimentation. There still remains an inexhaustible supply of material for new descriptive work, and all of the old material will have to be worked over again and again with the old methods but with new points of view. But in addition, we are recognizing in all fields of research that significant advance must now come from the adoption of the experimental method rather than from the older method on either old or new material.

It is probably a difficult matter to get an estimate of the results which scientific work, whether in the schools or in the shop and factory, is having in improving the habitual methods of thought and action in those pursuing it. I know of no reason for discouragement in this respect, though we may all regret that the results are not more marked, and may welcome such sympathetic criticism as Dewey has recently given in this connection. (Science Jan. 28, 1910.)

As to what biological science is doing in amassing information directly useful to man, it is hopeless to attempt a categorical account. In agriculture, horticulture, in plant and animal breeding, in relation to the cure and prevention of disease, and in allied fields, biological investigation is transforming our world. It is not too much to say that the advances in these lines are among the most significant facts of contemporary history. The work centering about the subject of heredity and plant and animal breeding is perhaps just now in the center of interest. On the theoretical side this work has of course raised about as many questions as it has answered, but the practical results of the careful study of hybridization and selec-

tion will soon be universally felt, and the possibilities now seem enormous. I mention this subject of heredity especially because it is such a capital illustration of the way in which years of independent and apparently unrelated work in taxonomy, morphology, cytology and embryology may come to converge sharply upon a definite problem of universal human interest.

Finally, what has biology done in giving us fundamental concepts which may dominate in our mental habits? We often say that great questions are likely to be decided by relatively trivial things, by the feelings of the moment, determined perhaps by the last previous meal or by the nature of our night's rest. In saying this we are doubtless taking the interesting exception as the rule. The educated man views his problems and determines his course largely by a few fundamental principles that have become part of his mental make-up. The special field of one's work may therefore readily affect one's general attitude by making its peculiar basic principles pronounced in him, quite as well as by the method with which it equips him. These broad principles naturally overlap in other fields, and the danger of not appreciating the differences in their applications to different materials is very great. It is the fortune of biology to have as its dominating concept the idea of genetic continuity in the forms which which it deals, a concept which after it has been vitalized by biological investigation has become quite as dominant in many other fields. The man who has once seen the organic world as the biologist sees it, who has some conception of the intricacies of phylogenetic relations and the factors concerned in development, is not likely ever to lose the dynamic point of view. He may not know as much as he would like to know of the political, social, or religious movements of the world, or of the philosophical systems which have held their sway, but his approach to all of these will be immeasurably improved if he regards this world in its forms and its activities as a "stage" in more than one sense of that term. In spite of the misconceptions arising from superficial contact with the facts, we shall not likely overestimate the beneficent results of the

general adoption of the dynamic view of the world and of our own ideas and activities. The adoption of that point of view may be obtained in any subject; it cannot well be missed in biology.

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2. The Relation of Pure and Applied Chemistry.

Julius Stieglitz.

One may consider applied chemistry to be chemistry applied to further utilitarian ends in manufacturing, commerce, agriculture, mining, medicine, and similar fields; pure chemistry as chemistry devoted to the discovery and spreading of truth irrespective of any question of commercial profit in it. The contrast, we note, is in the conscious aim and purpose of the chemist, a contrast, to use a trite parallel, akin to the common distinction made between murder and manslaughter, which differ, I believe, only in the intent of the slayer. But the *net result* of the act, one must remember, is the same in both cases. In the same way, it may be said if one considers pure and applied chemistry in their highest forms of development—and I wish to use the very short time at my disposal for the teatment of the large question before us from this single point of view—it would be extremely difficult in most cases to distiguish positively and justly wherein the *result* of so-called pure chemistry differs from the net result of so-called applied chemistry in their relations to the progress of knowledge and to practical affairs. It would be a most hazardous undertaking to predict what discoveries of pure chemistry will or will not sooner or later have effects which may be even revolutionary in their consequences in the field of commercial applications. It is not overstating the case to say that such revolutionary consequences have already followed in almost every branch of modern industry since the enunciation, some twenty years ago, of van't Hoff's theory of solution and as the result of the vast development of physico-chemical theory that has grown out of it. To give but a single, small, but significant instance, chosen because it is taken from the field of every-day occurrences, railway accidents, which one would suspect to have only the remotest connection with pure chemis-

try, I will repeat briefly the interesting account given by one of the chemists of the Illinois Steel Co. at a meeting in Chicago. Dr. Cremer told us how after a train had been wrecked by a broken rail, the results of miscrocopic examination of the rail, considered in the light of our physico-chemical knowledge of the conditions of equilibrium of the various components in steel, showed that the upper surface of the rail must have been subjected to a very high temperature and then suddenly cooled, with the result that the surface had been made brittle. Investigation showed then that the locomotive of the preceding train had taken in water in a violent snow storm and that the rail in question had been directly under the fire-box of the engine and when the train moved on, the falling snow prevented the required slow passage of the heated surface through the transition points of steel; the surface thus became brittle and the impact of the next train broke the rail by starting a fissure in the surface.

This is only a small instance of the profound change in methods of technical investigation and work which have followed van't Hoff's discovery of the laws of solution in the field of pure chemistry. On the other hand, Otto N. Witt, in the course of his work as expert in one of the leading aniline-dye manufacturing houses, in 1876 developed the fundamental points of a theory of the *cause of color* in organic compounds and the theory of their capacity to form dyes—theories, which, emanating from a technical chemist, have been of profound importance in the development of the pure scientific examination of the question, and form even after thirty years the basis for the present views on this subject. In developing for the Badische Anilin-Fabrik the contact process of manufacturing sulphuric acid, a process which is rapidly displacing the older, awkward, lead-chamber process, Knietsch, as he himself explains, was led from the beginning by considerations of pure theoretical chemistry; he was *not* led by the experience gained and conclusion reached by applied chemistry; on the contrary he had sixty years of practical failures and costly disappointments before him in the previous experiments of technical or applied

chemistry. And yet he persisted, secure in his faith in the predictions of pure chemistry. Who would say whether his triumph, which revolutionized one of our fundamental chemical industries, should form a further leaf in the laurels of pure chemistry or in those of applied chemistry? It would be impossible to say which parts of Professor Baeyer's classical researches at the University of Munich on the structure and artificial synthesis of indigo must be credited to the efforts of pure chemistry, which to the domain of applied chemistry; the investigations did, as a mater of fact, after some thirty years of conscious effort by Baeyer, Heumann and others, lead to the successful exploitation of the manufacture of artificial indigo on a scale which must finally bring about the disappearance of the natural article from the markets and make vast areas formerly used for the cultivation of the indigo plant available for the production of food. At the same time, besides these ultimate utilitarian results, these same researches of Baeyer led to such proprofound questions of pure chemical interest as the problem of the real structure of the benzene nucleus, the problem of polymethylene rings, of unsaturated carbon valences, of tautomerism as shown in enolic and ketonic forms, of acid amides and amido acids; all present day organic chemistry is permeated with results of that work on the structure and synthesis of indigo.

The same difficulty that confronts us when we attempt to distinguish in such great investigations between pure and applied chemistry and their relations to the progress of knowledge and to practical affairs meets us if we attempt to assign our great investigators to one field or the other: A. W. Hofman was equally successful in extending the lines of discovery into the great domain of organic nitrogen bases, which before him, had been practically a "dark continent" and in developing extensive and profitable manufacturing of aniline dyes: Baeyer pre-eminently a disciple of pure chemistry was, as we have seen, the originator of the line of work which has established the commercial preparation of artificial indigo: Bernthsen, professor of organic chemistry at

the University of Heidelberg, investigator and author of a standard text-book on organic chemistry, became the head of a great house at a salary said to be $25,000 a year. The enormous, indirect consequences of van't Hoff's work in industrial chemistry have already been referred to; but he has also been a most valued adviser of the great Stassfurt works in the exploitation of their salt deposits. The names of Perkins, Liebig, Pasteur, Liberman, Graebe, Tiemann, Moissan, Nernst, Bredig, Haber and others too numerous to mention are current in the texts of pure chemistry as well as in important chapters of applied chemistry. And today, Nef's present researches on the oxidation of sugars, carried out for the discovery of truth only, may have extremely valuable results in their application to the treatment of diabetes.

I have purposely dwelt on this side of the question before us, leading to the recognition of the very intimate, almost inextricable relations of pure and applied chemistry in their highest forms of development, in order to express explicitly the belief that the highest interests of chemistry, of our universities and lower schools, and of our commercial and national development, would be the better preserved, the clearer we are in our own minds that sharp lines of division between pure and applied chemistry are unnatural, unnecessary and undesirable. I have done this in order to present three conclusions as the logical outcome of such a point of view: In the first place, in this practical, fast growing land of ours, in which the quest for values that cannot be measured in dollars and cents, the quest for truth and beauty, is just beginning to have a footing and not too firm a one at that, it would be well for the irremediably practical man, if he must apply his own standard of measurement, to remember that the discovery of new truth for its own sake in the field of pure chemistry may well contain the germs of revolutionary developments enhancing the wealth of the nation in many directions; it has been true so often in the past in all sciences—as shown in the development of the telegraph, the dynamo, the wireless, in the development of modern methods in the steel, sugar, copper industries, in agri-

cultural chemistry that it would be folly not to believe in similar developments in the future. To give only one problem illustrating the point: it is well known that by ordinary combustion we use only a small fraction of the fuel value, of the energy, in our coal, say 10 to 17% of it, wasting no less than 80 to 90% of this, our most precious source of wealth. The electrical oxidation of coal ought to reduce this loss to a small figure, and with one stroke thus treble or quadruple the economic value of our great coal deposits; pure chemistry has indicated such a possibility and it is a question who will overcome the inherent mechanical difficulties first, the worker in the field of applied or of pure chemistry.

In the second place, the professor of chemistry, whose life is devoted to research as an article of faith rather than for utilitarian results, is an ultimate, unprejudiced court of appeal to which the public can resort in questions of great practical moment to its welfare. The best precedents of the past generations then rather rare, that university and college chemists hold themselves aloof from every kind of technical and commercial obligations and entanglements, is in our generation becoming the rule, rather than the exception; but these same men, who refuse tempting offers from private corporations as a matter of principle, are, also as a matter of principle, available for active service in the practical interests of the public. In the third place—and this is a main object in my argument —I trust that the future development of schools of applied chemistry in his country will be altogether along the lines of *graduate* schools of technology, schools which will prepare the technical chemist for investigation, train him to find possibilities of improvement, of development, even of revolutionizing the methods of work in his own fields, train him to test his reasoning closely by the result of experimentation. For such results the schools must not only give instruction in the technical methods of the day and a bare outline of general and theoretical chemistry, say in fields where they have already been applied in technical work but they must give in particular *the broadest and most thorough instruction in the purest type of*

pure chemistry; only by doing this can the fertilizing ideas of pure science be planted where they ultimately will be of use in the improvement of applied chemistry. Germany has recognized the high level of the training given by these means in its schools of technology by granting to its polytechnics the right to confer the doctorate of science on its graduates. America can be satisfied only when it has schools of technology on a level no lower than those which have contributed so much to the wonderful industrial success of Germany. In such schools, then, pure chemistry and applied chemistry would stand side by side, each giving its best to the student, each free to develop to the fullest extent, each ready to contribute to the progress of knowledge and to the advancement of practical affairs.

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3. The Relation of Pure and Applied Physics.

John Fillmore Hayford.

Pure science is an absolute prerequisite to the development of applied science. Both pure and applied science contribute directly to the progress of knowledge. Applied science has also an indirect influence on the progress of knowledge which is much more important than its direct influence. The very nature of our practical affairs, as well as our success in dealing with them, depends upon the state of our knowledge. Hence these four, pure science, applied science, the progress of knowledge and our practical affairs form a continuous line of related matters in which each is dependent upon all of those which precede it.

New discoveries in science, or more accurate determinations of known laws, are an absolute prerequisite to continued progress in applied science. If all discoveries in science should stop at the present moment, that is if all progress in pure science ceased, the progress in applied science would continue for a time at a decreasing rate, until the present acquisitions of pure science had been largely turned to the use of a man. The progress in applied science would then practically stop until new lines of application were opened by developments in pure

science. I make no attempt to estimate the time required to reach this state of stagnation in applied science. It is certain that the stagnation would come under the stated conditions. It is relatively unimportant how soon it would come. The important point to be kept in mind is that progress in pure science is absolutely necessary in the long run to progress in applied science.

It is this which makes it fundamentally important to encourage and to foster pure research in science in all feasible ways, by establishing well equipped laboratories, by organizations for research, by generous rewards to those who are successful in research, by every possible device to enable the exceptional man with unusual gifts in this line to devote his whole time in a favorable environment to pure research. An abundant harvest can not be gathered in applied science unless plenty of good seed is secured from pure science.

Although history shows that each discovery in pure science is ordinarily followed sooner or later by corresponding advances in applied science, yet it also shows that the lag which occurs between the discovery and its useful application, though sometimes short, is frequently very long. Applied science should be encouraged and fostered in order to shorten the lag. The application is as important to man as the discovery. Much less of genius is needed to make the application than to make the discovery. The rewards are also more obvious and more certain. On the other hand, the total amount of work awaiting the laborers in the field of application is very large and the total lag of application behind discovery is great. The harvest being gathered in applied science is much smaller than the possible maximum from the seed already furnished in pure science.

It seems to me that universities are responsible in part for the unnecessarily great lag of application behind discovery in science. The atmosphere of universities leads one to put strong emphasis on knowing and very light emphasis on doing, leads one to be rightly and fully appreciative of discovery, but to appreciate in a half-hearted way only the effective application of discovered truth. It tends to lead one to accord enthusiastic

praise to a Faraday, the discoverer, but to be mild and cynical in appreciation of a Westinghouse who makes applications of great value to man.

The history of any well developed branch of applied science furnishes illustrations of the relation which has been stated between pure and applied science, and of the variable lag of application behind discovery. A catalogue of the ways in which applied science touches and influences our practical affairs would be very long and would be a recital of ideas familiar to this audience. Most articles of food and all articles of clothing have been either improved in quality or reduced in labor cost by the accomplishments of science, and the same is true of practically every artificial object within your present range of vision. The stories of the railway, the steamship, the printing press, the telegraph, and the telephone have many times been told.

To stop here in our thinking, to stop with the contemplation of the accomplishments of science as seen in material forms, is to miss the most important features of the relation of science to the progress of knowledge, and to our practical affairs. The material accomplishments of science, engines, dynamos, machines, processes of manufacture, etc., are but the foundation of its influence in the world. The two hundred thousand miles of railway in the United States are much less important than the strong influence of these railways upon the spread of knowledge, the condition of the race, the development of character. Let us look beyond the mere material accomplishments of science to its all pervading influence upon civilization. Within the allotted time it is possible to indicate this influence in a sketchy way only, by a touch here and a touch there.

The locomotive, the marine engine, the printing press, and the telegraph have made all the peoples of the world acquainted and changed them from enemies into friends. The people of the United States and the Japanese, living on opposite sides of the world, are better acquainted and therefore more friendly today than were the French and the Prussians one hundred years ago, living as close neighbors. If two hundred thousand

miles of railway had existed in the United States from 1800 to 1860, the people of the North and of the South would necessarily have been so well acquainted with each other that the Civil War could not have occurred. All agencies which make different peoples understand each other tend to abolish war, for wars are based primarily upon the failure of nations to understand each other. Science by furnishing quick and cheap transportation has caused man to develop the travel habit, by putting printed matter within the reach of every one has made reading a habit of the masses, and by furnishing quick convenient means of communication, the mail and the telegraph, has produced the habit of keeping in touch with all the world. Thus science, by promoting mutual understanding between nations, has been the greatest of peace makers.

Science has also been very powerful as a peacemaker by producing such powerful weapons and such efficient means of concentrating quickly vast numbers of troops and their supplies that war is now so costly and so deadly that we can not afford to indulge in it.

In improving personal morals, as well as national morals, and thereby advancing civilization, the workers in applied science are extremely powerful. They build a smooth steel road and a one-hundred ton locomotive which draws a massive train at a mile a minute. Then it is found that the safety, the lives, of the hundreds of passengers on the train depend upon the quick and certain action of the man in the cab of the locomotive. He must not only see the faint danger signal within a few seconds, every time it appears before him, he must also act promptly and with good judgment, or pay the forfeit with his own life and possibly the lives of many others. This and other situations created by science, in which certainty and quickness of action of the nerves and brain are absolutely necessary, because great responsibility is concentrated in one man have been most powerful influences in changing this from an irresponsible, drunken world into a responsible temperate one. Contrast the sober alert locomotive driver of today with the drunken and relatively dull stage driver whom he superseded.

This was formerly a world in which the winner was the man with the brute strength and physical bravery which gave him the power to win in a hand to hand battle. It was a world in which all, even the fighters who secured the spoils and the kings who ruled the fighters, lived in comparative discomfort. It was a world in which the higher thoughts, aspirations, and the impulse to render unselfish service, which are the essence of civilization, came to but very few. The masses of humanity were too heavily loaded with hard labor, with real oppression from the classes above them, and with the effects of ignorance and superstition, to have a part in the crude civilization which existed. It was a world in which men knew only their nearest neighbors, in which nations perpetually fought against each other, in which each people was densely ignorant of every other and correspondingly suspicious.

The workers in pure and applied science, by bringing into general use a method of thought which is the antithesis of superstition, by providing efficient means of intercommunication and for the general diffusion of knowledge, and by turning the forces of nature to the uses of man, have changed this into a world in which the winner is the man who thinks clearly, controls himself, and may be depended upon, the man who serves rather than the man who fights. It is now a world in which millions live in greater comfort and security than did even the kings of the ages before the scientist. It is now a world in which the average man works such short hours and under such comfortable conditions that he has abundant opportunities within his reach to share in the real benefits of civilization, to develop himself to his full capacity.

Possibly it may seem that I have exaggerated the influence of science upon the progress of knowledge and its influence in changing the very nature of practical affairs. In terse statements there is apt to be some exaggeration. But I challenge a critical examination of the thesis which has been put forward that the progress of civilization in the past century has been founded upon science and would have been impossible without science.

4. The Relation of Pure and Applied Science in Education.

Cyril G. Hopkins.

The dative of indirect object is used with most Latin verbs compounded with ad, ante, con, in, inter, ob, post, pre pro, sub, and super, and sometimes circum; the elements essential for the growth and maturity of the plants which furnish, directly or indirectly, the food and clothing for the human race are carbon, hydrogen, oxygen, nitrogen, phosphorus, potassium, magnesium, calcium, iron, and sulfur, and possibly chlorin; and I think I am expected to discuss the general question whether there may be as much educational development in a study of these elements, for example, and of their application to the preservation of American soil and to the preservation of American prosperity, civilization, and influence, as in learning a like number of Latin prepositions and their application to language development, and to philological research.

The question is, whether the culture of corn roots and the investigation of corn-root insects and diseases or the culture of clover roots, with their millions of symbiotic bacteria and their wonderful power to transform much of the improverished lands of that part of Illinois whose name is Egypt, and much of the exhausted and abandoned lands of India, whose fame is famine, into fruitful and valuable lands, may serve as well for the development of the mind and for the advancement of education and civilization, as the culture of Greek roots, and Sanskrit roots, and Hindu roots, from which we learn that the people of India, of whom only one man in ten, and only one woman in a hundred are able to read and write,—from which we learn that these people are our own cousins; that many words still live in India and in America that have witnessed the first separation of the northern and the southern Aryans; and, in the words of Max Muller, "these are witnesses not to be shaken by any cross examination. The terms for God, for house, for father, mother, son, daughter, for dog and cow, for heart and tears, for axe and tree, identical in all the Indo-European idioms, are like the watch words of soldiers. We challenge the

seeming stranger, and, whether he answer with the lips of a Greek, a German, or an (East) Indian, we recognize him as one of ourselves. There was a time when the ancestors of the Celts, the Germans, the Slavonians, the Greeks and Italians, the Persians and Hindus, were living together beneath the same roof."

Why has the southern Aryan civilization developed but one school for every five villages, while the northern Aryan, save in Russia, opens to every child the door of the school which leads on, for those who will, to the college and university? Why? Because only a prosperous nation can afford the trained intelligence or education of its people.

Education in America is not the cause but the product of our prosperity; and, thus far, the prosperity of this nation is due to our conquest of the former inhabitants, and the uninhabited wilds, and to the consequent acquisition of the great natural resources of this country, including primarily vast areas of rich virgin soil; and secondarily immense supplies of timber and coal.

American prosperity has done more than educate Americans; it has educated western Europe, first of all by relieving the over-crowded condition of those impoverished lands, and subsequently by making large direct contributions to European prosperity, in supplying cheap food and fertilizer and a good market for European products, manufactured in large part from the low-priced raw materials secured from this and other new countries.

Applied science has already made some contributions to American education and civilization, and so far as its use in the school room is concerned, applied science, as an educative agency, is not exceeded in value by any other instrumentality. Its very general acceptance by teachers and students in our leading educational institutions does not prove its value, but does prove that its value is being appreciated; and I need not remind you that pure science is the foundation of applied science.

While education has not been in any sense the prime cause

of our national prosperity, the future prosperity of America depends absolutely upon the application of science and education to industry. For three full centuries America has lived upon the spoils of conquest and inherited wealth and resources, and for three full centuries America has wasted her substance or scattered it abroad. But even among nations there is a limit to inherited wealth. The land which flowed with milk and honey is now almost a barren waste, supporting only wandering bands of marauding Arabs and villages of beggars.

Truly the two most characteristic attributes of rich young America are wastefulness and bigotry. Other nations have risen to positions of world-power and influence and fallen again to poverty, ignorance, and insignificance. Thus far American history has been in large part a repetition of the history of nations long since gone to decay.

Following the rise and fall of the great empires of Babylon, of Carthaginia, and of Greece, the Roman Empire also rose and fell. From what cause? Some tell us that the fall of those great empires was due to the development of pride and immorality among their peoples, forgetting the fact that civilization tends rather toward peace and security, and that universal education depends and must depend upon material prosperity. Poverty is at once helpless and soon ignorant.

History tells us that Roman agriculture declined until a bushel of seed brought only four bushels in the harvest, declined until the high civilization of the Mediterranean countries passed into the Dark Ages which covered the face of the earth for a thousand years, until the discovery of a New World brought new supplies of food, renewed prosperity, and new life and light to Western Europe; but the Dark Ages still exist for most of your own Aryan race in Russia and in India, where, as an average, day by day, and year by year, more people are hungry than live in the United States, where the average wage of a man is fifty cents a month, where famine rages always, and where the price of wheat sometimes rises to a point where six months' wages of a working man are required to buy one bushel. This is the condition where the absolute needs of the

population exceed the food supply; and just so sure as the intelligent and influential men and women of America continue to ignore the material foundation upon which national prosperity depends, just so sure will future Dark Ages blot out American civilization.

That most of the lands that were once cultivated with profit in the original thirteen states are now agriculturally abandoned is common knowledge; that much of the land in all adjoining states is in the process of abandonment is known to many; and that the common lands in the great agricultural regions in central United States are even now in process of the most rapid soil depletion ever witnessed is known to all who possess the facts.

Already the question of food has begun to exert pressure in this country. Already the masses, the common people, the "ninety percent," must consider a reduction in their standard of living. Poverty and degeneracy are even now making such demands upon the revenues of the state that education and research already suffer from inadequate support; and the only hope of the future lies in the application of science and education to the control of industry and to the control of population; and let us never forget that agriculture is the basis of all industry, and that the fertility of the soil is the absolute support of every form of agriculture.

Some will say that the economic conditions have been such that the depletion of the lands of the eastern states has been a necessary sequence, and that the restoration of those lands will now follow as an economic necessity. I beg of you, do not accept any such theoretical deductions. If systems of permanent progressive agriculture are ever to be adopted anywhere in this country, it must be done while the landowners are still prosperous. Some investment is necessary for the restoration of depleted soil, and poverty makes no investments. Much of the abandoned lands of America are far past the point of possible self-redemption. They were depleted not because of any economic necessity but because of ignorance, and the fault lies not with the farmers and landowners, but with the educators

who even until the present generation have taught almost everything except the application of science to agriculture. The fault lies also with the statesmen who, as James J. Hill says, have "unduly assisted manufacture, commerce, and other activities that center in cities, at the expense of the farm."

There was no need whatever that the cultivable farm lands of the eastern states should have been depleted. Lying at the door of our greatest markets, with the application of knowledge and with such encouragement as should have been given, those lands could easily have been preserved and even increased in fertility until their present value would have been not five dollars but five hundred dollars an acre.

Even now are the young men of the United States putting ninety million dollars a year into Canadian farms. Why? Because they were not taught in the schools that by investing those millions in the application of science to agriculture they can remain in the United States and secure greater profit and also save our soils from depletion; yes, make our partially depleted lands even more productive than they ever were, and at the same time provide the food that will soon be required to feed our own children.

Why do we premit the annual exportation of more than a million tons of our best phosphate rock, for which we receive at the mines the paltry sum of five million dollars, carrying away from the United States an amount of the only element of plant food we shall ever need to buy, that, if retained in this country and applied to our own soils, would be worth not five million, but a thousand million dollars, for the production of food for the on-coming generation of Americans?

Why this exportation? Because the present owners of American land learned only the art of agriculture and were never taught the science of farming; and it may well be repeated that the responsiblity rests not with the farmer, but with the statesman and the educator.

Note well the following facts:

During the past dozen years the average acreage in corn and wheat in the United States has been increased by 30 percent;

but notwithstanding the enormous increased production thus made possible, we have been obliged to decrease our average exportation of corn and wheat from nearly one-fourth to only one-tenth of our total production; and at the same time the average price of these great basic food materials has increased by 52 percent, corresponding approximately to the increase in the value of land in the great corn and wheat states, and to the consequent and inevitable general advance in the cost of living.

You will remember that the population of the United States has increased 100 percent in thirty years, and without doubt will number more than ninety millions in 1910; but, notwithstanding the great areas of rich virgin lands brought under cultivation in the West and Northwest, and notwithstanding the abandonment of great areas of depleted soil in the East and Southeast, during the last forty years the average yield per acre of these two great grain crops has not even been maintained according to the twenty-year averages of the crop statistics of the federal government for the forty years from 1866 to 1905, as reported in the 1908 year book of the United States Department of Agriculture.

Shorter periods might be selected which would give apparent indications of a different tendency, but less than 20-year averages are not trustworthy for ascertaining the average yield per acre; and these two 20-year averages show that the decrease in yield of corn has exceeded the slight increase in yield of wheat, much of which, it should be remembered, is now grown on land less than forty years under cultivation. And this statement holds not only for the entire United States, but also for the great North Central grain belt, including Ohio, Kansas, North Dakota, and the ten other states lying within that triangle.

Thus, in this boasted "granary of the world," the records of forty years show that the average yield of wheat has increased one-half bushel per acre, while the average yield of corn has decreased two bushels per acre.

Why should the average yield of corn in the United States

be only 25 bushels per acre and the average yield in Illinois be only twenty-five bushels per acre and the average yield in Illinois be only thirty-five bushels per acre, when the average yield upon the farm of the University of Illinois, on normal soil under practical, profitable and permanent scientific systems of farming is eighty-seven bushels per acre?

There are at least four factors involved in the solution of the problem of maintaining prosperity, civilization, and universal education in this country. These four factors may be classified as exploitational, scientific, legal, and economic.

1. Further exploitation of our remaining virgin soils, as by irrigation and drainage, neither of which is of large significance in comparison with the magnitude of our present agricultural development.

2. The restoration, by practical scientific methods, of depleted lands and large increase in productive power of practically all lands now under cultivation. This is the only great positive factor.

3. The legal control of increase in pouplation by the enactment and enforcement of suitable laws.

4. The reduction in the standard of living, by extending the tendency already enforced to some extent, as in the gradual withdrawal of meat and other valuable food products from the daily diet, and adopting such standards as are common in China and Japan, where beef, butter, and milk are practically unknown.

The greatest study of mankind is not man, but the application of principles upon which depends the preservation of man's prosperity and civilization; and this study must not only include the application of science to raise high the limitations of the production from the soil of necessary food supplies, but it must also include the application of sense in placing some just and necessary limitations upon the reproduction of the least fit of human kind.

5. The Relation of Pure and Applied Science in Secondary Education.

Worrallo Whitney.

The field which the subject of this symposium covers is so great that, for the limited time at my disposal, it seems best to confine my inquiry to some one phase of the question. I have chosen, therefore, a topic that has interested me for some time, one which is finding expression among science teachers in the agitation for a general science course for the first year of the high school course of study. I shall inquire into the position of science in the curricula of the high schools, especially as to whether science is receiving the attention it deserves in comparison with its importance in every day life and in comparison with other departments in the high school. The question also as to whether the applied sciences now being added to the curricula of many schools are being articulated with the pure science courses already in the course of study is an important one.

It does not seem very necessary to call attention to the increasing importance of science in every day life. Every one is familiar with the facts of the achievements of science, especially those that are spectacular, but these achievements are becoming such an every day matter, taken for granted that one must pause to think, before he realizes fully how far-reaching the field of science really is, and how fast it is increasing these days, with the advances in electricity, transportation, gas, sanitary and medical science, agriculture, forestry, etc. Take the one field of sanitary science; the advance from simple guess work to accurate scientific knowledge has meant the saving of untold thousands of lives, and its work for good has just begun. Its field is in every home, of more importance in the homes of the ignorant and poor than in the homes of the educated and rich.

Few can doubt that agriculture will, in the near future, be rescued from the ruts into which it has fallen on account of the virgin fertility of the soil and put upon a scientific basis. Many are beginning to recognize that the hope of a prosperous future of our country depends upon this.

In view of the supreme importance of science in life, one

would expect to find it occupying a commanding position in the curriculum of every secondary school. But educators are conservative. Tradition and custom are binding forces that tend to hinder rational response to changed conditions. A glance at the history of educational methods shows this tendency toward conservatism to be very strong.

In mediaeval times education was solely for those who did not work with their hands. The classics furnished the basis for educational training, for indeed there was little else, and it answered the purpose. In time, human freedom gradually broadened and with it education reached down from the idler and scholar to the workers. As education became more widespread and free schools established, the number fitting for college greatly increased. Finally, little more than a half century ago the first public high schools were established. But instead of these schools growing up out of the elementary schools, they were patterned after the colleges.

The colleges had been the bulwark of conservatism, and till a few years ago, comparatively, the classics still held their place in the front rank of what was deemed best for educational training, almost a fetich to the educators of the colleges. The men who were called to make the curricula of the high schools came from the colleges, and we need not be surprised when we find the languages still occupying the front rank in the high schools, even more than in the colleges themselves.

Let us now inquire into the actual conditions we may find in the curricula of the high schools. I will first analyze the course of study of the Chicago high schools, since I am more familiar with these schools. Some explanation of terms is necessary for a clear understanding of the figures. High schools usually give one credit toward graduation for five recitations per week in one subject for a year, two laboratory periods counting as one recitation period. Manual training, music, drawing, and domestic science usually required two periods of work as an equivalent to a recitation period. The unit course then is five recitations per week in one subject for one year. But as a few schools, including those of Chicago, have many courses

with only four or even fewer recitations per week, giving however corresponding credit, it will be more convenient in this paper to use hours (periods) in place of unit courses, understanding that five hours constitute a unit course.

Chicago offers a total of 211 hours work, about forty-two courses, in her high schools, not including manual training which is localized in a few schools, and omitting domestic science and art which are not fully organized. By departments the courses are distributed as follows:

Foreign language.....91 hours, or about 45% of the total number of hours offered.

English	16	hours, or about		8%
History	20	"	"	10%
Commerce (including arithmetic)	26	"	"	13%
Mathematics	14	"	"	7%
Science	24	"	"	12%
Music, drawing, etc.	20	"	"	10%

The cultural subjects, language and history, constitute 63% of the total courses offered against 37% in all other subjects. It will be noticed, also, that the commercial department, one of the most recently established, offers a greater number of hours than science, twenty-six hours of commercial work to twenty-four hours of science, and this is counting physiology, geology and astronomy as sciences though they are not usually given with laboratory courses in the Chicago schools, and should really not be counted as science. Excluding these subjects, Chicago offers only nineteen hours work in the laboratory sciences. Excluding from the foreign language group Greek and Spanish, which are not given in most of the schools, Chicago offers 57 hours in foreign language to 19 hours in science, exactly three to one.

In order to compare this with other schools of the state I sent out fifty requests for courses of study, twenty-five to township high schools and twenty-five to city and village high schools and received forty replies. With these forty courses of study I constructed a table showing the number of hours

offered in each department and showing also the distribution of the science courses offered by each school.

Studying this table I find that the ratios remain about the same as in Chicago except that there are fewer courses in the foreign languages and often more in the sciences (not including domestic science). The courses offered in the foreign languages in the various schools range from 20 hours to 95 hours in amount. While the courses offered in science range from 15 hours to 35 hours, averaging 41 hours of foreign language to 23 hours of science. No distinction is here made between laboratory science and text-book science, since many of the courses of study did not indicate the methods used in the school. Physiology is required and is usually given without an accompanying laboratory course. I estimate that 20 hours is about the correct average of the laboratory sciences, or about 13% of the average total number of hours offered.

Of equal importance with the amount of time given, and growing directly out of this, is the organization of the courses. In Latin, for example, we find a well organized four year course, each succeeding year building on the work of the preceding year, the whole forming a graded series with one object in view. The same is true of the other foreign languages and of English as now taught in the schools. In history the courses are consecutive, beginning with ancient history and ending in most schools with American history and civics. In even the latest subjects to be added to the curriculum as in the case of the commercial department, most schools offer a graded series of four to six unit courses preparing for business life.

Now, how is it with science? We find four years work usually offered, consisting of physical geography and physiology in the first year, botany and zoology or a year of either in the second, and physics and chemistry or chemistry and physics in the third and fourth years. This is not, in any sense, a graded course as in Latin, German and other subjects. It is rather a series of fragments of science, with a half year or a whole year devoted to each fragment. The series cannot be called a four year course comparable with the courses in other

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departments. The principal value of Latin as an educational factor in high schools has been due not so much to any intrinsic merit in the study *per se,* as to the carefully graded work on one single subject for four years, thus giving time and opportunity for cumulative development and disciplinary training of the mental activities of the pupil. What would be thought of any school that offered four or more one-year courses in as many languages as a substitute for the usual well graded courses now offered? I wish to quote a passage from a recent address by [1]Professor John Dewey on this point. He says, "Imagine a history of the teaching of the languages which should read like this: 'The later seventies and eighties of the nineteenth century witnessed a remarkable growth of the attention given in high schools to the languages. Hundreds of schools adopted an extensive and elaborate scheme by means of which almost the entire linguistic ground was covered. Each of the three terms of a year was devoted to a language. In the first Latin and Greek and Sanskrit were covered; in the next French, German, and Italian; while the last year was given to review and Hebrew and Spanish as optional studies.'" This imaginary picture by Dewey vividly illustrates the position of science at the present time.

How has it happened that the four sciences are arranged as they now are for the order given above is the usual one? Is it due to grading, forming a graded course in any strict sense of the word? I think not. Any one acquainted with high school science work knows that this arrangement depends upon other factors and not upon anything inherent in the subjects themselves. Take chemistry and physical geography, one usually given in the fourth year and the other in the first year. Chemistry could be adapted to first year grade just as well as physical geography so far as anything in the subject itself is concerned. But it happens that chemistry requires a more expensive laboratory and small classes, while physical geography requires a relatively less expensive equipment, is less expensive to run, and larger classes can be handled. Botany and zoology do not

1 Science, Jan. 28th, 1910, page 124.

necessarily depend upon anything taught in physical geography. Physics is given late in the course of study because the college requirements are so stiff that the work cannot be done in the first year. In fact the physics teachers of Chicago find it easy to arrange a course in physics for a proposed first year general science course. I think we can take it as proved that the sciences do not form a graded course comparable with courses in other departments and that the present arrangement is due primarily to extraneous factors such as cost of laboratories, size of classes and college entrance requirements.

It cannot be said, however, that school officials in planning courses of study consciously intended to slight the sciences. The fault is largely due to the newness of the sciences themselves. There has been action and reaction both in content and in methods of teaching of the sciences, and the end is not reached. The present laboratory method of teaching science in secondary schools does not date back two decades, while the classics have had the advantage of centuries of teaching, in which a great body of principles and methods has been firmly established. But it appears that school authorities have settled down to the belief that this fragmental practice of teaching science is sufficient, for we see a great uniformity in courses of study in this respect. The only straw that indicates a measure of dissatisfaction with the present arrangement lies in the agitation for general science courses in the first year of high school. A few schools have already established such a course.

A good test of the inadequate organization of the science courses is the manner in which the new courses of applied science are being added to the curricula of many schools. I refer to domestic science and agriculture. One would naturally expect that when these sciences are added to the curriculum of any school, they would be articulated with the existing courses in pure science. Before a pupil enters upon a course in an applied science, he ought to have received training in scientific method and habit of thought by studies in pure science, preferably of course in those sciences that underlie the applied science in question. Thus chemistry and botany at least should

precede or accompany domestic science courses and all the biological and physical sciences are necessary to adequate teaching of agriculture.

But instead of an attempt to establish well graded or correlated courses of this sort, in which the pure sciences are prerequisite to or coordinate with the course in applied science we find that the new courses are usually being added without any reference to existing courses in pure science. Among the 40 courses of study I have examined, only two have any specific requirement of a pure science as a prerequisite. In Chicago, a four-year course in domestic science is being planned with no requirements in other sciences. Such extended courses in applied science must of necessity repeat, in a more or less complete way, science work which is already being done in the pure science or might be done readily if there were concerted action. This is surely a waste of effort.

But the case with agriculture is much stronger. We may have agriculture of a sort, but not "scientific" agriculture without the training and facts yielded by the pure sciences. Yet so-called courses in agriculture are being added as if the science were wholly unrelated to other sciences. Often these courses are placed in the early years of the course of study, where it is not to blame for the way it is being done. The arrangement any preliminary training in science. The result is, of course, a very superficial and unscientific kind of training.

But, after all, the school officers who are placing these new courses in the curriculum in reponse to the demand for them are not to blame for the way it is being done. The arrangement of the pure science courses does not offer any chance for the development of well graded courses in the applied sciences. Chemistry, which is needed in both agriculture and domestic science, is given in the fourth year in most schools and physics in the third year. Neither of these studies as now given can be utilized.

Another testimonial to the inadequate and unscientific organzation of science in secondary schools is seen in the establishment of separate schools of agriculture and other industrial

and technical schools of secondary school grade. These schools are a waste of the resources of the state, for they duplicate the regular schools in all respects save the one department. They are deterimental also in developing a false notion of the relative importance of the various departments of learning. The establishment of these schools is direct condemnation of the existing systems in the regular schools. The reason is not far to seek. The curriculum of the average school is not flexible, on the contrary it is so fixed that needed changes for adjustment to new relations cannot be made without a serious fight with the "ins." Rather than have this fight with an inflexible system, resort has been made to separate schools. Those who have the interests of the public high schools at heart should see to it that there is proper response to the demand for the teaching of agriculture and other industrial subjects in high schools. It should be met by honest endeavor to adjust old relations to new demands, else separate schools are bound to come with consequent division of funds and effort. I may add here an interesting fact in our experience in botany classes in Chicago. Of late, boys in our botany classes are strongly attracted by the advantages offered in scientific agriculture, forestry, and sanitary science. This movement is quite marked though we give only one year of botany with little that suggests agriculture in it. It is a trend country-ward from the city of city youth, in contrast with the usual movement.

We may now summarize the points I have made with respect to the position of science in secondary schools. First, the time usually given to science is very small in comparison with the importance of the subject and in comparison with the cultural subjects, averaging only one-half to one-third the time given to foreign languages alone. Secondly, the science courses as now planned are fragments of larger subjects and not enough time is spent on any one of them to secure good results either in disciplinary training or in information. Third, the science courses do not form a graded orderly development of knowledge such as we find in other departments. Each year's work is a detached piece and contributes but little to any other year's work

in science. In consequence of the limited time given to each science, there is an attempt to cover too much territory in the allotted time. The pupil, instead of feeling the growth of power and grasp of the subject, is apt to be overwhelmed and paralyzed by matter that he cannot assimilate. Fourth, the pure science courses are organized in such a way that courses in applied science cannot be articulated with them and cannot take advantage of the expensive laboratory equipment of the pure sciences. Fifth, the inflexibility of the curriculum and the inadequate organization of the science courses have resulted in the establishment of many separate schools of agriculture and other industrial sciences.

It is not within the province of this paper to propose remedies for the cure of these defects. If a solution of the problems were easy, it doubtless would have been hit upon long ago. In closing, however, I would like to suggest what I think are the lines the reorganization of science must tae. These lines are first, foundational science in the first year of the high school; second, more time for each of the pure sciences; third, courses in applied science should be articulated with the pure sciences; fourth, all high schools in towns and cities tributary to agricultural districts should have a carefully planned course in agriculture and sufficient farming land for practical laboratory work.

It has been indicated that elementary physics and chemistry should be given in the first year as a foundation for courses in applied sciences and for the pure sciences as well. I would suggest a half year of physical geography, made less technical than it is usually given, followed by a half year of elementary physics and chemistry, this to be perequisite for all science courses, or a full year of general science consisting of physical geography and biology the first half and physics and chemistry the second half. In this latter case a more advanced type of physiography could be given later in the course. Physiology, now required in the first year, should follow zoology in the third year, but if it cannot be taken from the first year then it might be given without home work in informal lectures on hygiene and physiology, as an extra, time being

given for it from the home work of all the other studies of the first year. It is now usually given in a perfunctory manner from a text-book and the method I suggest would be more dignified and beneficial, especially if physicians were invited in to give many of the talks. By this or some similar device the continuity of the science courses could be preserved.

Botany and zoology occupy at present an advantageous position that probably cannot be bettered. I would, however, give two years to each. The second year in botany could be given to systematic and economic botany, preparing the way for agriculture. A good second year's work in zoology would be formed by giving a half year to study of insects and economic zoology and a half year to vertebrates with special reference to physiology, including human physiology. In physics there is plenty of important work in electricity and other topics. But these are merely suggestions of my own. The great need is for careful study of the situation and experimentation with a view to improving not only the organization of the courses but also the methods employed in presenting the various sciences.

No one can justly say that this proposed increase of the science would burden the course of study for we have only to look to the foreign language courses to get a refutation of such a charge. The cost would be but little greater, nothing at all except perhaps in physics. The added time for better developed courses and the cutting out of hurry and scrimping will add dignity, interest and attractiveness to the courses in science and greatly increase their value. It has been found in the past that increased facilities for education always meet a prompt response in increased patronage. So with increased facilities and saner methods would come greater appreciation of science and still greater appreciation of the work the high schools are doing for the people.

S. A. Forbes.—"The series of able and really brilliant papers contributed to our symposium this morning are a justification of the symposium idea, and also of the judgement of the council in their choice of a subject. It seems that the council

needs defense against the reflections of some of the speakers upon the form and wording which we gave to the topic of discussion. We agreed among ourselves that there was no dividing line or essential difference, in the last analysis, between pure and applied science; but this is not the common view, and we really set ourselves up as a target to draw the fire of our symposium speakers, as a means of demonstrating the fallacy of the common view.

Mr. Coulter has a resolution in hand, which, as it applies to the subject of scientific education, may be offered here."

In the absence of John G. Coulter, John M. Coulter persented the following motion, notice of which had been given at the Friday meeting by the former. *Moved*: That the President shall be authorized to appoint a committee of five, to discover whether the Academy may be of assistance to the high schools of the State in the teaching of science; and, if so, to report at the next meeting a plan of action; and that the Council shall be authorized to place at the disposal of this committee such funds for its expense of correspondence as may seem expedient."

This was voted and the President appointed the following committee: Cyril G. Hopkins, J. F. Hayford, John G. Coulter, Worrallo Whitney, W. S. Strode.

The Secretary inquired after the addresses of some of the members whom he had been unable to locate. He expressed a hope that at some time during the meeting opportunity might be found for a discussion of the needs of the Academy, stating that at no time since the organization meeting had there been general opportunity for individual members to offer suggestions.

T. W. Galloway reported on additional names recommended for membership and the persons named were elected.

W. S. Strode reported for the Auditing committee as follows:

Your committee appointed to examine the books and acounts of the Treasurer J. C. Hessler have done so and found the same correct."

Isaac E. Hess presented the following paper:

THE PASSING OF OUR GAME BIRDS.

What has the future in store for the game birds of the Mississippi valley? My paper will refer in particular to the resident game birds: the prairie chicken, ruffed grouse, bobwhite and woodcock.

Of the migrators, including such species as Wilson's snipe, golden plover, yellow-legs, and the several ducks and geese, there is no immediate danger of extermination.. Just so long as these birds extend their summer range beyond the bounds of man, the long black lines and curves and angles of migrating birds will continue to be seen traveling northward in the spring and returning each autumn.

When civilization has followed them until farther northward is denied, then will their numbers fade away like those of the beautiful wood duck; and like the passenger pigeon they will gradually disappear.

Time was, and not in the distant past, when prairie chickens and quail were more common in the fields of the prairie states than domestic fowl about the barnyards. Several times within recent years, bobwhites have so rapidly increased as to excite comment from even non-observers, only to be swept away in such an avalanche of destruction, that the following season they are rarely met with. And nature is his great destroyer, not man.

The winter of 1902-1903 was a fair illustration of how nature performs her work of equalization. In the fall of 1902 bobwhites were more numerous, with one possible exception, than any other bird of central Illinois. A walk through any stubble or meadow would send at least one flock scurrying to shelter, and a ride along country roads would reveal covey after covey runing along the hedge rows; while dozens would be

Fig. 5. Prairie Chicken (*Tympanachus americanus.*)

seen hurrying across the road ahead of approaching teams. The winter was moderately mild until February, when one evening came a heavy fall of snow and the thousands of bobwhites, out battling with the elements, burrowed to the bottom of the snow-banks for warmth and shelter.

During the night the wind shifted and a rain and sleet set in. In a short time the tunnels were covered with the drifting snow, and by morning a thick hard crust of ice imprisoned the little bands of living pulsing creatures. A new experience now confronts them and they huddle close together. Their world has narrowed to small proportions, but they are warm and comfortable, and the first day passes with little inconvenience. But prison without succor means death, and slowly but surely the little flocks succumb to the pangs of hunger. With horns of plenty all about them, they gradually starve, and not until the warm spring winds unlock the prison doors, do we behold the awful results of nature's tragedy.

The bobwhite army quickly recovers, however, from these terrible reverses, and two or three good seasons are sufficient to restore them to their former numbers, as they rapidly multiply. If the sumer season be dry and favorably, two sets of eggs will be deposited, and each female will bring forth two broods averaging fifteen chicks each.. The first brood will hatch in late May, and the second in early July. Twenty chicks of the thirty should arive at maturity, and if the winter season be not of the quail killing sort, a dozen should survive its rigors, leaving seven pairs to begin the following season. Computing by compound interest, these seven pairs should increase to 606 birds by the third season. With one pair of quails on each section of land, one township should furnish the enormous number of 21,816 birds in three productive seasons.

Is it not plain that without the intervention of nature, quails would soon become more numerous than the grasshoppers in the fields, and in the course of events would prove a serious menace to the harvests?

But nature does not need the help of man in her work of reducing the over supply to normal conditions, and when man

interferes, the result is sometimes extinction.. Nature has seldom caused the extinction of species since the modern era, but through human agencies alone has disappeared the great auk, the passenger pigeon and the Carolina parroquet.

From man the bobwhite, however, has little to fear, and for this reason he seems to have brighter prospects than the other game birds about us. The day is past when he furnishes the zest for the hunting trip. Through wise legislation, the time for shooting him has been diminished, until now he is protected nearly eleven months of the year.

Another point in his favor is the growing sentiment that he should not be considered a game bird. His economic value has been established, and this with his inocent harmless life has appealed to those who used to seek his life, and many hunters now will allow a fine covey to flush at their feet with never the temptation to lift a gun. As one old hunter said, "Did you ever dress a pretty little quail and find its crop bursting with weed seeds of which it had kindly cleared your land? And did you stop to think that for the fun of killing and for two or three ounces of meat—delicious, it is true—you had destroyed a friend that was working hard every day in your interest? Well, that is my experience, and I must say it took some of the zest of quail shooting away, when I thought of what I had done."

The prairie hen has had a harder row to hoe. That noble bird has been forced to adapt itself to a violent change of conditions since the days when it felt so much at home in the broad expanse of rolling prairies.. The fates have been unkind to it and its enemies relentless. Big and strong and swift of wing, it has furnished rare sport for the hunter, and the flavor of its flesh has found great favor with the epicure.

With its enemies so much in evidence, the natives seeking it for food, the hunter shooting it for sport, and the pot-hunters slaughtering it for gain, it has been running a continual gauntlet.

Add to this the constant danger confronting the young prairie chickens from their natural enemies, the foxes, minks,

skunks, weasels, and hawks, and the difficulties the hen must meet in saving her eggs from the ravages of cows, snakes, and squirrels (to say nothing of the farmer's plow), and you need not think it strange that the prairie hen has been unable to hold its own. No more do we see those great flocks, numbering in the hundreds, sailing rapidly over the fields to their feeding grounds. Only little bands scattered here and there are left of that vast army of birds so conspicuous in the early settlement days. They have been rapidly disappearing of late years, and it seemed for a time that their days were surely numbered.

Fortunately, however, the legislature of Illinois became sufficiently alarmed to pass a law protecting this bird for a period of years, giving it in this state at least a new lease of life. The next few years will determine whether or not the prairie chicken is doomed to destruction. If the clause be not renewed, this pioneer bird will pass into history. A renewal of the law at its expiration July 1, 1911, for an additional five years will give him another chance in the great battle of the survival of the fittest.

If the prairie chicken is a native of your locality, you will know it about the last week in February.. It is then you may hear the loud drumming noise made by the male at the first signs of opening spring, and be enabled to number and locate each flock in the vicinity. If you have never seen the male at his drumming, you have missed a novelty indeed. On either side of his neck is a large yellow spot devoid of feathers. The skin is quite loose and very elastic and capable of being blown up like a small rubber balloon. As the cock struts to and fro, displaying his many charms before a bevy of admiring females, these wind-bags are distended to the size of oranges.

With his head swaying back and forth near the ground, the drumming noise is made by expelling the collected air through the mouth. Beginning about four o'clock in the morning, the cocks drum with marked regularity until six or after. On still mornings they may be heard at a distance of three or four miles.

His "boo-ro-roo" is a long-drawn out roll, and resembles nothing so much as the expression "you-ole fool." Indeed, when the drumming is followed with these syllables in mind, the resemblance is ludicrous. Not the most gallant way perhaps, for father Tympanachus to announce to the sleeping world the birth of a new day, but really quite excusable when we think of his many trials and crosses at the hand of man. It is, in fact, his only way of resenting the plowing up of his foraging grounds and the turning of his nests in the furrows.

To see him in his most interesting moods, you must find him during courting hours. Then the determined swains meet in battle royal to decide the great question as to which shall be "king of the flock," the victor of course claiming the choice of the females for his mate.

When you have gazed upon the proud fellow dragging his stiff wings on the ground in scornful challenge; when you have seen the excited cackling females encouraging their lords to battle and have heard their wild nerve shattering laughter (so like the babble of a gathering of maniacs), you will have felt repaid for the inconvenience of an early morning trip to the rendevous.

The bobwhite and prairie chicken may both be saved to us by simply protecting them. That they are gradually adapting themselves to the changed conditions is amply proved. Recently I found a nest of the prairie hen containing thirteen eggs placed in a small clover field within a hundred yards of our town park, and last summer I photographed a nest with eggs only four blocks from my place of business. Bobwhite is already a semj-domesticated bird and will nest and feed in company with the barnyard fowl when undisturbed.

The ruffed grouse and woodcock, however, will soon be gone. The only possible way to keep them would be to save the forests, and this of course will not be done. These interesting game birds cannot change their mode of life, and man's advent was the beginning of the end for them.

I have in mind but one spot where I may now find the woodcock, that queer almost silent bird of the night. Untouched

by the woodman's axe, a bit of forest in its primeval state still shelters a thick swampy undergrowth. The soil remains wet and soft throughout the summer season, and here where the woodcock may penetrate its oozy depths with his long soft mandible he feels at home. When the last of these wild spots of nature is gone, then will the woodcock be no more.

The passenger pigeon is gone, and now it does not lie within our power to bring back the magnificent flocks that used to darken the sun for our ancestors. Perhaps my hearers have noticed the desperate efforts that are recently being made in behalf of the passenger pigeon. Offers of hundreds of dollars are made to the public, not for the dead body of this now rare bird, but merely for the evidence that a single one is in the land of the living. Excellent motive, but too late! too late! Wise legislation a score of years ago would have prevented this fine bird from extinction.

We of Illinois have an apportunity to improve upon the lax methods of twenty years ago. This is the age of conservation of resources. We have tasted of the fruits of carelessness. Are we to learn from experience?

The past months of December and January, with their abnormal periods of ice and snow, have wrought sad havoc among the quail of the north Mississippi valley. It is doubtful if any season of recent years has proved so disastrous as the one just past. Reports from all over the state tell the same pitiful story of covey upon covey of bobwhites found huddled together, all dead.

I think it is obvious to us all that without protection for the bobwhite at this stage for a period of three years at least, we shall be in danger of losing for all time this valuable citizen.

Through the protection of the prairie chicken during recent years, this part of Illinois (at least Champaign county) may claim a very appreciable increase in numbers. Just as they are geting a good start, we are confronted with the knowledge that the protective clause expires on July 1st of next year. Listen while I tell you of a secret. Within six miles of the University of Illinois, at this moment there is a grand flock of

sixty of these splendid birds that have successfully coped with the severe winter months.

Gentlemen of the Illinois Academy of Science, how many of you would wish to see that band of pioneer birds exterminated within a month from July 1, 1911?

I have a letter in my pocket from W. F. Henninger of Ohio, who is Secretary of the Wilson Ornithological Club of that state, stating that he seriously doubts if a single live prairie chicken is now to be found within the boundaries of Ohio. Is this to be said of Illinois in the near future??

I would be much pleased should the Illinois Academy of Science go on record as favoring the repeal of the quail law for a protecting period of three years, and an extension of the prairie chicken protecting clause for an additional period of five years from July 1, 1911.

W. S.. Strode.—"The quail is holding his own pretty well since the farmer is awakening to the fact that he is a very useful bird, destroying great quantities of weed seed, chinch bugs, and other obnoxious insects. The Cooper's hawk and sharp-shinned hawk are great destroyers of the quail. The former will eat nothing else if he can get a quail every day, and the latter is no better.

Only absolute protection to the prairie hen will result in its introduction again to the prairies of Illinois, as it is a conspicuous bird, an easy mark, and a touch of shot kills it. The average boy with his automatic or pump gun would quickly get the last of a flock.

The ruffed grouse is almost extinct. Some years ago in Fulton county a disease broke out among them and destroyed nearly the last of them.

The wild turkey is practically extinct in the state and can never successfully be introduced again as their habitat has been destroyed. The speaker killed his last one on Christmas day 1883, and then awoke to the fact that he had killed the last one in Fulton county."

I. E. Hess.—"We have a legislative committee, and I move that they be instructed to see what steps can be taken to have the game law so modified as to offer quails absolute protection for three years and prairie chickens for five years." The motion was carried.

F. C. Baker.—Moved, "That a committee be appointed to look into the matter of permits for collecting birds and their nests and eggs, and to ascertain if a law is feasible for the absolute prohibition for a period of years of the collection of birds and eggs by all, excepting by accredited scientific institutions; or if this prohibition be not desirable, that efforts be made to secure the substitution of the Illinois State Academy of Science as the issuing agent for the permits, in place of the existing agent."

President Forbes appointed the following committee: F. C. Baker, Isaac E. Hess and Fred L. Charles.

P. B. Hawk presented a paper of which the following is an abstract:

FURTHER STUDIES ON THE INFLUENCE OF COPIOUS WATER DRINKING WITH MEALS.

The subjects of these experiments were young men who were placed on a uniform diet, and all urine and feces were collected in twenty-four hour periods and analyzed. Each experiment consisted of three parts, a *preliminary period* of six days during which time the subjects were brought into "nitrogen equilibrium." During this period 900 cc. of water was daily ingested, 300 cc. of this amount being taken with meals. The second period or *"water period"* was five days in length and during each of these 1000 cc. of water above that already mentioned was taken at each meal. The *third period* was from three to eight days in length and during this period the amount of water ingested was the same per day as in the preliminary period. The daily drinking of three liters of water with meals, for a period of five days by these three normal young men, who

were in a condition of nitrogen equilibrium through the ingestion of a uniform diet, was productive of the following findings:

1. An increase in body weight, aggregating from one and one-half to two pounds in five days.

2. An increased excretion of urinary nitrogen, the excess nitrogen being mainly in the form or urea, ammonia and creatine.

3. A decreased excretion of creatinine and the coincident appearance of creatine in the urine. The decreased creatinine output is believed to indicate that the copious water drinking has stimulated protein catabolism. The appearance of creatine is considered evidence that the water has caused a *partial* muscular disintegration, resulting in the release of creatine, but not profound enough to yield the total nitrogen content of the muscle. The output of creatine is therefore out of all proportion to the increase in the excretion of total nitrogen.

4. An increased output of ammonia which is interpreted as indicating an increased output of gastric juice.

5. A decreased excretion of feces and of fecal nitrogen the decrease in the excretion of fecal nitrogen being of sufficient magnitude to secure a lowered excretion of both the bacterial and the non-bacterial nitrogen.

6. A lower creatinine coefficient.

7. A more economical utilization of the protein constituents of the diet.

8. A decreased excretion of fecal extractive nitrogen.

9. A strikingly lowered output of carbohydrate in the feces, thus indicating a more economical utilization of the ingested carbohydrate.

10. The increased body weight; the lessened output of feces and fecal nitrogen; the decrease in bacterial and extractive nitrogen of the feces; the more economical utilization of the protein and the carbohydrate constituents of the diet, all continued throughout the final period on a plan similar to that established during the water period, instead of returning to the conditions in force during the preliminary period. These facts indicate that the influence of the water is not simply temporary.

11. The general conclusion to be reached as the result of these experiments is contrary to the current medical teaching, and is to the effect that the drinking of a large amount of water by normal individuals, with meals, was attended by many desirable and by no undesirable features.

Q. I. Simpson presented the following paper:

BIOLOGY AND OTHER SCIENCES AS APPLIED BY A BREEDER.

About the time when Dr. Burrill was teaching *all* the sciences at this university, a professor of Natural Science, my father, was leading a class of six, all the product of his own loin. He taught causality for all nature's phenomena, the immutability of law and universal kinship. Hence the application of science to our life work.

Two centuries of nursing, pampering and inbreeding of the English thorobred had brought the foals to almost the delicacy of *Homo,* and the country "hoss" doctor and our own experience could not cure their many baby ailments. But *"kinship"* brought the village physican, and our losses were then at an end. The Government, after many researches concerning hog cholera, had discovered an impractical form of immunization, and had put out a *drug* formula for cure and prevention that was as useless as a *drug* cure and preventive for small pox. We were lost and feared we must lay aside the most profitable money maker of the farm. But we read how a physician in Georgia had lowered the death rate in typhoid by abstinence from all diet. We had seen the bacteria of typhoid and of cholera in a Government laboratory, and noted that they were in appearance alike. Dissection of our swine showed that they were diseased as described for typhoid. The intestines were weakened by numerous little boils, so that a little pull or pressure would produce a hole which allowed foods to escape into the abdominal cavity. Even the pulling of the lateral and longitudinal muscles which causes peristaltic action was sufficient to tear these tissues. Then we *fasted* all cholera swine and the

disease to us lost its terror. We do not court this enemy, but by the application of strict quarantine prevent it, or hold it to a particular field or pen. A neighbor, his dog, or horse, or vehicle, from a cholera farm would be as little welcome at our farm, as would a leper at our residence.

I am proud to know that Illinois has now a better method of preventing great loss from cholera, in the immunization now being directed by Dr. Peters, and which has been so well established by Dr. Connaway of Missouri.

The isolated farmer has not the "atmosphere" that you men of the universities have, and you will laugh at our modes for research and inspiration, but when we looked thru the libraries for laws and rules and principles governing breeding, we found just one, handed down from Aristotle, the law that like begets like; and it is a lie.

It seems that most of the research, which during the last half century has changed biology, was instigated in some way by the great truth propounded by Charles Darwin. He and Mendel brought life down from the clouds where thinking men may handle, analyze, and theorize as they do in the exact sciences of dead elements. The sexual principles of Gregor Mendel were the first that were absolutely true in their application to the breeding of plants, animals, and man. They were given before the Society of Brunn in 1865, but lay unnoticed until the spring of 1900, when three papers by DeVries, Correns, and Von Tschermak were published stating again its substance. Each of these three writers was able to confirm Mendel's conclusions from his own cases.

At this time Spillman was developing these laws in wheat hybrids, and they were almost immediately confirmed by Castle, Bateson, and others with small pet stock. Your writer, on a farm, isloated from learning and with little scientific literature, did not hear of these principles until he read an article by Castle in 1904. We had been making a variety of hybrid experiments with swine; using pedigreed animals of strongly contrasted visual features, partly for determining the economic value of their many mixtures, but chiefly to determine the then mooted

question of sex value, the relation of potential between male and female, and when we read thees laws we had in our fields a half hundred pig hybrids proving their truth and accuracy.

We at once became Mendelian enthusiasts; for these were the first proven laws for the guidance of heredity characters. We do not now require Pearson biometries nor Galton tables, but try to simulate the chemist, physicist, and astronomer by direct application, borrowing the principles of exactness and law from kindred sciences.

With Mendel's laws we five years ago propounled the theory of magnetic-polarity, the why-for of sex as shown by the action of chromosomes at fertilization and thruout all the mitotic divisions and reproductions of the cell, to old age in the individual. And the theory has been established by other lines of research under the more general name of "the electrochemic theory of life." This was well illustrated by Dr. Lillie at the Boston meeting of the A. A. A. S. recently, in a paper on fertilization, wherein he showed how the entrance of a single sperm negatively polarized the egg against further encroachment.

When we learned of Mendel laws, we had in our group of pig hybrids much diversity and non-correlation of characters on single individual hybrids, which told us that the conception of the half nuclei was an insufficient explanation. . Some experimenters and cytologists were claiming that the independence of the finer division of these half nuclei—the chromosomes—were the origin of the independant unit characters that showed a non-correlation with other characters from their four grandparents. In our first reprints sent to Mendelian and cytological workers, many of these men would advise us "to go slow with the chromosomes as bearers of heredity; that we are not yet sure that they are the vehicles." But further hybridizing of strongly contrasted breeds and the aggregating of three and four of these contrasted breeds in a single hybrid brood has enabled us to almost count the chromosomes, and convince *ourselves*, if none else, that *they* are the *things* that *do it*.

From these experiments and the Mendel-chromosome combination of theories, we are now able to analyse supposedly pure animals and prove and name their specific impurity. We are doing it now with swine purchased from reputable foreign breeders with the exactness and surety of a chemical laboratory.

Many experimenters are using the same methods under different terms. The "allelomorphs" of Bateson and Castle and the "factors" of other experimenters are proof of the chromosomes' action. The direct experiments of myself that have cost me far more work than a doctor's title, have enabled me to say that the individual, independent chromosomes of the male and female nuclear colonies are the things that determine units of heredity.

With this chromosome-Mendelian-unit-seggregation-idea, we are synthesizing the units from various individuals as does the chemist; and building animals to "blue print" as does the architect. And when built, we then with these same principles and some empirical knowledge test the individual as to the purity and homogeneity of its inner germs.

With these we do not fear *latency, reversion,* or *throwing back,* and can create *reversion* at will when so desired. We can formulate new "made-up breeds" to suit the economy or the fancy. We can fix these breeds in the purity of their characters with certainty and precision, without the long line of inbreeding, as used by disciples of Aristotle. We are working in an advanced field on a dim trail, and must use every finding from kindred experimenters that will lead the way.

The climatic mutants from Tower's potato bugs, the mutants of Webber's frozen orange stump, the variants from McDougal's chemical plants, and the feather-pigment researches, by Riddle, are all telling things that relate to our work of creating pigs to order; and show that life is only a chemical laboratory and subject to chemical and physical laws.

Weismann brought Mendelism into unity, by showing that *albinos* were of *no* pigment; and *whites,* like white hogs and white leghorns, an over oxidation of pigment, a fading out to white. This explained the *dominance* of *white* hogs,

and the *recessiveness* of *albino* mice, when crossed with pigment. His graduation of pigment colors worked out in the chemical laboratory agree, in my opinion, with Emerson's and Shull's hypostatic and epistatic grades of pigment in bean hybridizing, and the dominant and recessive colors in swine of our own mixtures.

Men with biometrics had found little gain from outcrossing corn, but the precise individual methods of Dr. Shull and Dr. East in producing absolutely pure types, and crossing these, have brought this grain under the general law of "magnetic polarity," the out-cross rejuvenation as found in crossing inbred animals. Former experimenters had been trying to inbreed hybrids (corn with *biotypes*), and it was like the inbreeding of the Collings nondescript short horns, *not* inbreeding.

The facts found by cytologists that all animal cells from paramecium to man inclusive, and all plants above bacteria contain chromosomes; that they show precise division and reduction of these at prefertilization, and an exact fixed number in all germ and somatic cells of any particular variety of plant or animal; and that they constitute a mode of reproduction of these chromosomes, has led us to offer a theory, which I gave at Omaha. This tries to account for the mutability and varietal changes of organisms by explaining the chemical and miscropical action of the finer details of these organisms. Unless we can guess the specific units that make and regulate life, we will be hardly able to make and control it to our own particular fancy. The chemist and physicist have found usually that what nature can do man may also accomplish when he learns how she has done it. That she has and is doing things in the lines of mutability in life we have abundant proof.

When we had apparently found to our satisfaction that the chromosomes are the builders of the cells, then we asked how they do it. And this I will try to tell you, accepting the hypothesis that the chromosomes are bacterial catalytic entities, and act on the blood or lymph of animals and the cell sap of plants, analysing and synthesizing the chemical cytoplasm of the cells, as their kindred the bacteria work chemical change in a jar of

agar, or starch solution. Boveri in the year of 1888 had said "The splitting of the chromosomes appears to be a vital manifestation; an act of reproduction on the part of the chromosomes." And every authoritative cytologist since has said that they divide and reproduce by fission, making two from one. But some of these have thought that they sometimes arise anew from simple cytoplasm, because they have not found them under certain conditions in some cells.

McClung, Wilson, Miss Foote and Miss Stevens have found that sex is determined by the odd or even number of these chromosomes; and all the direct breeding experiments of artificial mutability of individuals have led to this idea of their bacterial semblance.

When we consider the embryo's development from a fused germ cell, and the many different chemical forms of hoof, hair, pigment, bone, and glandular cells, we must surely ask if there is not something inside these particular cells that works a chemical change, or metabolism, on the homogeneity of the common lymph and common sap.

We were ready to spring this theory of "the bacterial semblance of the chromosomes" a year ago, but some cytologist said these chromosomes at times lose their identity. Further work in complicated hybrids of contrasted breeds, enabled us to nearly count these chromosomes by the non-correlation of distinct and heritable units. We searched volumes on chemistry for a perpetuating chemical enzyme. Platinum finely divided and some sulphates would work catalytic change on lymph, sap, or starch solution, but would not reproduce.

There is but one reproducable catalyser yet known, the hated bacteria. So by the logic of simple elimination we attribute to bacteria the building of plant and animal cells from the undiferentiated lymph or sap that filters thru the cell wall into the cell. First the lymph exists as cytoplasm. Then after metabolism by bacterial chromosomes it becomes pigment, bone, hoof, or epithelium. Since this theory was given at Omaha, we have found much further confirmation, and we are receiving support from able men.

We had assumed that a bunch of bacteria had balled-up and by secretion of slime, had caused the first cyst or cell sac. Dr. Condon and Dr. Fischer showed us there was not need for the assumption, for there are now in the evolutionary stage capsulated and non-capsulated bacteria in single species. An editorial in the Journal of the Am. Med. Assn. of Dec. 18, 1909, gives Jensen's classification of bacteria and their supposed evolution into higher plants and animals.

The theory that we present is in substance that the chromosomes are the vital entities that make life, and that carry heredity from germ to maturity and from generation to generation. These chromosomes are of bacterial evolutionary origin, yet retain the bacterial properties of creating metabolism. In the slow reproduction of germ cells from the blastomere to the ovary or testis, thru only a line of epithelial cells, they do not change their species, but in the rapid division of the somatic cells mutate into the various properties required for the particular cells which they build.

In conclusion, I wish to express a breeder's gratitude to you scientific workers, who by your exact methods of thought and research and your accomplishments set example to the slip-shod methods of my class, and show us what may be found by direct experimentation. Our application of evolutionary kinship we owe to the precision of the systematist. The Mendel laws, by which all accurate determination of the action of genetic units is derived, was formulated by a trained botanist. Proofs of the cause for these laws are obtained with the aid of the microscope by workers of your universities. Most that the breeder has obtained since Aristotle's time has been learned from trained scientists.

The meeting then adjourned till 2 p. m.

Afternoon Session.

After the calling to order by the Chairman, upon motion of T. W. Galloway, the committee on Ecological Survey was continued.

Notice was given of opportunity to visit the Mine Rescue Station.

F. C. Baker presented a paper which is given in abstract below:

THE ECOLOGY OF THE SKOKIE MARSH AREA WITH SPECIAL REFERENCE TO THE MOLLUSCA.

The present paper is an attempt to place on record a minute study of a small territory with special reference to its molluscan inhabitants. The area chosen is in the Skokie Marsh Region north of Chicago. The territory actually surveyed included a tract of land three miles long and one mile wide, extending from Glencoe west to Shermerville. It is situated in the Glacial Skokie Bay, which, by natural drainage, has become a swamp of large extent. Three streams traverse the area in a southerly direction: (1) a small stream through the center of the marsh near Glencoe, which is for the most part of a transient character; (2) the east branch of the Chicago river; and (3), the north branch of the Chicago river, flowing through Shermerville. This area divides into five subordinate areas: A, the marsh, which is low and wet with the characteristic Typha and Calamagrostis plants; B, an intermediate ridge west of the marsh, which is low and wet on its eastern edge, but which rises to a height of twenty feet above the Skokie stream on its western edge; this region contains several forested areas of oak, cottonwood, maple, elm, and other large trees; C, the east branch of the Chicago river which embraces a wide flood plain bordered by rather high terraced banks, and supporting a characteristic swamp and bog vegetation, notable among which is the button-bush; D, a large area west of the east branch, which rises to a height of forty feet above the river and is heavily forested with large trees of elm, oak, cottonwood, maple, etc.; E, the north branch of the Chicago river, which flows through a flat, more or less marshy plain.

Each of the above five areas is divisible into several stations,

each more or less characteristic. Thirty-six such stations have been closely examined and a study made of their biotic contents. The mollusca were exhaustively studied, the associated animals (as birds, reptiles, batrachians, insects, and crustaceans) being also listed. As a study of animal ecology is not complete without a consideration of the associated plants, this important branch of biology has been studied and lists made of the important plant societies.

A taxonomic study of the mollusca of this region shows the collections secured to embrace two classes, three orders, fourteen families, twenty-three genera, thirty-eight species and varieties, all living within the area three miles long and one mile wide. Of interest in this connection is the discovery that, apparently, several species in two families were founded upon age variation. One, *Lymnaea reflexa* Say, included *Lymnaea palustris michiganensis* Walker (young) and *Lymnaea crystalensis* Baker (immature); the other, *Physa gyrina* Say, included *Physa oleacea* Tryon (immature.) Twenty terrestrial and eighteen fluviatile mollusks were identified.

The typical molluscan societies and their habitat relations may be summed up as follows:

TERRESTRIAL SPECIES.

In swamp with Typha or Iris.

Succinea retusa, Succinea avara, Agriolimax campestris.

On low ground subject to overflow.

Agriolimax campestris, Polygyra thyroides, Polygyra fraterna, Pyramidula alternata, Zonitoides arborcus, Vitrea hammonis.

On higher ground, raised above overflow.

Succinea ovalis, Agriolimax campestris, Polygyra albolabris, Philomycus carolinensis.

On dry ground.

Strobilops virgo, Helicodiscus parallelus, Vitrea indentata, Euconulus fulvus, Bifidaria contracta, B. pentodon.

Living under "started" bark, etc.

Zonitoides, Vitrea, Strobilops, Helicodiscus, Vertigo, Euconulus, Bifidaria, and *Carychium. Pyramidula* is frequently found

under "started" bark, and *Polygyra albolabris* haunts holes and large crevices in dry weather.

FLUVIATILE SPECIES.

Found in all varieties of habitat.

Physa gyrina.

In large summer-dry ponds.

Physa gyrina, Planorbis trivolvis, Planorbis parvus, Planorbis exacuous, Segmentina armigera, Musculium partumeium, Ancylus parallelus, Lymnaea reflexa.

In small pools of very transient character.

Lymnaea caperata, Aplexa hypnorum, Sphaerium occidentale.

In the river, which does not run dry.

Sphaerium stamineum, Musculium transversum, Lampsilis, Anodonta, Anodontoides, Physa gyrina, Planorbis trivolvis, Ancylus rivularis.

Semiaquatic; on the edge of river and pools.

Lymnaea parva sterkii.

In brooks and overflow from river.

Lymnaea caperata.

C. W. Andrews.—"Is Skokie Marsh connected with the outer belt area in Chicago?"

F. C. Baker.—"It is."

Victor E. Shelford presented an illustrated paper of which an abstract is given below.

ECOLOGICAL SUCCESSSION OF FISH AND ITS BEARING ON FISH CULTURE.

The investigation with which my paper deals is not yet completed. The results are too extensive for reading before the Academy. Accordingly, only an abstract of the chief facts and conclusions is given here. The completed work will be published elsewhere later.

I. DEFINITION. Ecological succession differs from geologi-

cal succession or the succession of species, in that species may be ignored, except as names are necessary, and only the *habits* of the forms taken into consideration.

II. AREA STUDIED. The area studied is at the head of Lake Michigan where deposition of sand and the recession of the lake have caused the formation of a series of long sloughs parallel with the shore. Attention has been concentrated on the first, fifth, seventh, and fourteenth of these, as counted from the lake. The first is youngest. The fifth may be considered as at least five times as old as the first; the seventh, seven times as old; and the fourteenth, fourteen times as old.

III. SUCCESSION. Slough XIV was once in the same stage as slough I, and was then occupied by fish ecologically similar to those in slough I at present. The vegetation grew and humus accumulated, making it impossible for the ecological types of slough I to continue, and these were succeeded by the ecological types such as we now find in slough V; in due time these gave way to the ecological types in slough VII, and these likewise to those of slough XIV.

IV. CAUSES. This includes causes of succession of fish, and the factors governing the distribution of fish with reference to the disappearance of the food fishes (large mouthed black bass, the green sunfish, and bluegill) from the sloughs as they grow older or in other words their absence from all but slough I when they colud have gotten into the other until recently, when certain railroad culverts were discontinued and filled.

1. *Size and depth.* It is not due to their selecting the largest and deepest bodies of water. These fishes are found in the shallowest and smallest of the ponds (slough I).

2. *Chemistry of water.* An analysis has shown difference too slight to be recognized by fish.

3. *Food.* The fish are not where the food supply is greatest.

a. Food has been shown to be greatest in the sloughs which do not contain these fish.

b. The fish food consumed in each slough is about the same, but the consumers in the older sloughs are different and undesirable fishes.

c. The fish food supply is greatest in the older members of another series of ponds studied for comparison. In these fishes are numerous in the older ponds, and fish are almost absent from the youngest which is artificial. The greatest food supply in the older sloughs is not, due therefore, to the absent of the fish in question, but to *other causes*.

4. *Living place of the fish.* The fish are not in the situations which they are known to frequent in large bodies of water, as these situations are not present in slough I, but are present in the others.

5. *Breeding place.* These fish are known to breed chiefly on bare bottom. The vegetation and humus which come with age *destroy bare bottom and hence fish breeding places.* Slough I is the only one having extensive bare bottom. The fish in question are in the pond containing suitable breeding places, to the neglect of other factors.

V. CONCLUSIONS. 1. *Scientific.* The breeding habits and distribution of suitable breeding places are the first factors in the distribution and succession of fish, as has been shown for certain beetles and is held for birds. This is crucial to ecological study.

2. *Economic.* a. These data indicate clearly that the prooduction of food fishes of a given area depends upon the availability of suitable breeding places.

b. Economic effort should be directed toward: (1) The study of the behavior of fish, especially during the breeding season. (2) The cultivation, preservation, and protection by legislation of the breeding places of food and game fishes.

The following paper was presented by Frank C. Gates:

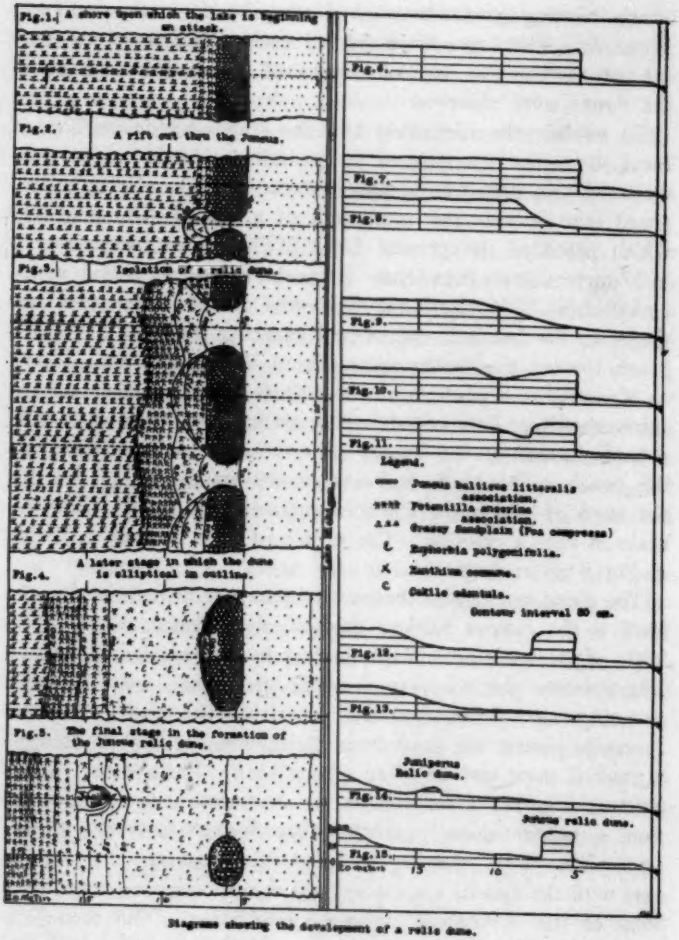
RELIC DUNES, A LIFE HISTORY.

A relic dune is a mound of sand left for a time during the washing away of a beach. It is but a temporary stage even when well protected by an efficient plant covering. The relic dunes with which this article deals are to be found along the

western shore of Lake Michigan from Kenosha, Wisconsin, down to the Illinois-Wisconsin state line. In that locality the shore is being gradually washed away by the action of Lake Michigan. The dunes were studied during 1908 and 1909, during which time the complete stages of destruction of some of the dunes were observed.

To explain the formation and the stages of destruction of these dunes, it is necessary to go into the historical development of this part of the lake shore. This beach is the exposed lake bottom and sand bars of a glacial Nipissing lake which preceded the present Lake Michigan and was from 3 to 17 meters above it in level. Since the low-water period, which ended about 1896, the rising waters of the lake have been cutting into the beach in places and carrying the sand along the beach toward the southwards. From Winthrop Harbor north to Kenosha is a place where the shore is being washed away fairly rapidly. When such action commences, there is usually a bluff formed at the line of contact of the storm waves and the beach. The bluff, however, is maintained by plants, for the sand of which the soil is composed will not of itself remain in such a position. The profile of such a beach is shown in Fig. 6 of the diagram.

The plant association that is all important in maintaining the bluff is the *Juncus balticus littoralis* association. From 97 to 99% of the individual plants belong to that species of *Juncus*. The rhizones form a very dense tangle, which not only helps to protect the beach from the attack of the waves, but also serves to protect the sand from desiccation, for dry sand forms a gradual slope instead of an adrupt bluff. Back of the *Juncus balticus littoralis* association is the *Potentilla anserina* association, a narrow zone, separating the *Juncus* from the grassy sand plain which stretches back for many meters. As was the case with the *Juncus* association, the facies comprises more than 80% of the *Potentilla anserina* association. The secondary species which make any showing whatsoever are *Monarda punctata, Sporobolus cryptandrus,* and *Cenchrus carolinianus*. Both of these grasses usually occur in the tension zone between



Diagrams showing the development of a relic dune.

this association and the grassy sand plain. This later association is composed of over 90% of *Poa compressa,* which, however, does not grow sufficiently thick to prevent the sand from giving the color tone to the area. Secondary species appear scattered throughout, but they are never of much importance, as they occur only as individuals here and there in the grass. Some of the most frequently occurring secondary species are:

Euphorbia corollata,
Verbena hastata,
Erigeron canadensis,
Verbascum thapsus,
Cacalia tuberosa
Monarda punctata,
Pycnanthemum virginicum,
Panicum (?pseudopubescens),
Isanthus brachiatus,
Erigeron divaricatus,
Poa pratensis,
Rumex acetosella,
Achillea millefolium,
Anaphalis margaritacea.
Oxalis stricta,
Lobelia spicata,
Scutellaria parvula,
Hypericum kalmianum,
Potentilla arguta.

The most important secondary species of this association from the view-point of this article are *Juniperus horizontalis* and *Juniperus communis depressa,* because they are the only secondary species that can form relic dunes. There are a few mats of each of these junipers at intervals in the sod. These together with the *Juncus balticus littoralis* are the only species which, in this region, are instrumental in the formation of relic dunes.

With this brief consideration of the physiographic appearance of the region and the plant associations which occupy it, the steps in the formation of the relic dunes are now in order. In places where in every storm, not merely the more violent ones, the waves attack the bluff, sooner or later passageways or rifts will be cut thru the *Juncus* association. This allows undermining of the sand plain, whose surface is sparsely covered with vegetation, the roots of which have but a very limited sand-binding capacity. Consequently the plain is washed away as far as the waves have power. A few of the stages that follow are shown in the accompanying plate, in which the structure of the surface is shown on the left, and on the right selected profiles have been constructed.

The sand from immediately to the landward of the *Juncus*

is carried into the lake in the backwash of the waves, thus leaving a mound of sand, thoroughly permeated with *Juncus* rhizomes and usually having a coat of exposed rhizomes, which become dry under the desiccating action of the wind and sun.

At first the relic dunes are elliptical in shape, with their major axis parallel with the shore line. By washing away the ends, however, succeeding storms reduce them to an approximately circular outline. In this form they may endure for a couple or more years, depending upon the violence of the storms.

The relic dune itself is a mound of sand about 2 meters high and about 2.5 meters broad. At the top is a very dense growth of *Juncus balticus littoralis,* whose rhizomes thoroughly permeate the dune. At the outside the exposed rhizomes, which usually form a rather dense matwork, protect the dune from both the desiccating and mechanical effects of the wind. From the attack of the waves the rhizomes are of relatively smaller value. The sides of the dunes are cut out in grooves, especially near the bottom where the wind and wave action is more pronounced. A few secondary species occur on the cap, such as *Sporobolus cryptandrus, Cornus stolonifera, Calamovilfa longifolia,* and *Salsola kali tenuifolia,* but the number of individuals is so small that they are of relatively no importance

The *Juniperus communis depressa* relic dune, of which at the present writing there is only one in the area, is a poorly developed dune near the limit of wave action. The roots of this plant have not the sand binding power that those of the *Juncus* have. Consequently any exposed sand would be blown away. As the sand is removed by blowing or otherwise, the outermost branches of the juniper sink down and cover the sides of the mound with vegetation which protects it in quite a fair measure from much further action by the wind. Toward the west or landward side the prevailing westerly winds keep piling up sand faster than the juniper can cover it up. Within the next few years, if the present rate of erosion continues, there will be seven or eight more relic dunes of both species of juniper, at which time a better understanding of this class of relic dunes will be possible.

The destruction of the relic dunes takes place thru the same agencies that were instrumental in their formation. The wave action during violent storms is one of the most potent agencies of destruction, both because of its mechanical force and the ready movement of sand grains when submerged. The wind in general acts as a desiccating agent, but obtains direct action where the sides of the dunes are unprotected. As the surface dries, the outside grains no longer stick to the moister ones within, but either fall to the base of the dune because of gravity, or are blown away by the wind. This method of destruction is very slow because the dunes are abundantly supplied with water by capillary attraction from the water table, by spray blown in from the lake, by the quite frequent rains of this region, and by dew which is often deposited upon them during the nights when the sand cools down much faster than the surrounding air.

A more violent, though rather infrequent agency, is the disruptive power of freezing water. In instances of the action of this agency in 1909, the dunes were thoroughly soaked by a heavy rain, which was followed immediately by a drop in temperature from 0.5° to 12°C, the result of which was the cracking of the dunes. The broken pieces were like rocks on account of the ice, but as soon as the ice at the surface evaporated, the wind scattered the loosened sand grains over the surface of the beach. Several of the smaller relic dunes were thus disintegrated during November 1909. The larger dunes merely suffered the removal of 10-20 cm. of sand from around the edge of the crown. The vegetation of the rim slipped down and now serves to protect the dune during the winter.

In the part of the area which has been under consideration, the lake is advancing upon the shore rather rapidly, so rapidly that the *Juncus*, even with its relatively rapid means of vegetative propagation, has been unable to retreat. It merely holds the ground upon which it had formed a zone parallel to the shore line. Consequently, as soon as the *Juncus* relic dunes are destroyed, the *Juncus* association will become non-existent in this particular area. The *Potentilla anserina* association, on the

other hand, spready by seeds as well as vegetatively. It has widened out from a strip 0.5-1.0 meters wide back of the *Juncus*, to large mats 5 to 7 or more meters in diameter, which occupy the sand area between the relic dunes and the grassy sand plain. The maximum development occurs just below the grass. Where it overlaps into the grass the vegetation is noticeably heavier than in either of the two associations. This is aided by a few secondary species, especially *Sporobolus cryptandrus* and *Monarda punctata*. The grass (*Poa compressa*) forms a permanent vegetative covering, but the *Potentila* dries up during the winter. During the growing season much blowing is prevented by the covering of *Potentilla*, but with the removal of this in the fall the blowing of sand commences, and during the winter the amount that is blown away is noticeable. Much of it tends to accumulate southward of this area.

From the state line south to Winthrop Harbor the shore dips away from so direct an attack from the waves. Here the *Juncus* is able to retreat from the shore line, and although relic dunes still are being formed, there is still a relatively wide zone of *Juncus* behind them which protects the grassy plain from being washed away.

T. E. Savage presented the following paper:

THE GRAND TOWER (ONONDAGA) FORMATION OF ILLINOIS, AND ITS RELATION TO THE JEFFERSONVILLE BEDS OF INDIANA.

The name Grand Tower formation was proposed by Keyes[1] for the Devonian strata in southeast Missouri, which were considered the equivalent of the Onondaga and the Oriskany of the New York section. The name is taken from the town of Grand Tower, in Jackson county, Illinois. The term is here amended to include only that part of the Devonian strata in southwest Illinois, and adjacent portions of Missouri, which is the western representative of the Onondaga

1 Keyes. Mo. Geo. Survey, Vol. III, p. 330, 1894.

limestone of New York. The name Clear Creek formation has been applied to the Devonian beds in Illinois that correspond in age with the upper Oriskany portion of the New York Devonian.

DISTRIBUTION AND CONDITIONS OF DEPOSITION.. The Grand Tower formation, like the lower Devonian strata in Illinois, is thought to have been laid down in a narrow arm of the sea that had connection southward with the Gulf of Mexico. It is found in our state over only a small area in the extreme southern part. At the base it consists of 25 to 30 feet of sandstone, which is succeeded by about 125 feet of limestone, making an aggregate thickness for the formation of about 155 feet.

The sandstone of the Grand Tower formation overlies the Clear Creek, or Upper Oriskany, beds with no intervening break in sedimentation. The quiet conditions under which the Oriskany strata were deposited in this region were broken by a movement to the westward, in Ozarkia, which increased mechanical sedimentation over this portion of the basin. The movement was intermittent, and resulted for a time in the deposition, along the west border of the embayment, of layers of sand containing a mingling of Onondaga and Oriskany fossils, alternating with periods of quiet during which limestone layers, containing typical Oriskany fossils, were accumulated. As a result, there is in this region an interwedging of the upper layers of the Oriskany and the basal portion of the Grand Tower strata along the zone of contact of these formations. Eventually sand deposition prevailed, and there was spread over the basin a mantle of sand 20 to 30 feet in thickness, which constitutes the lower member of the Grand Tower formation. This sandstone is exposed in the southwest part of Jackson county, and at numerous points further south, in the counties of Union and Alexander.

After the deposition of the basal sandstone, there was a further movement in the Ozarkian region of Missouri, that resulted in pushing the west shore of the sea further eastward in southern Union and in Alexander county, and put a

stop to sedimentation in that portion of the basin during all of the remaining Onondaga time. In the vicinity of Grand Tower, and in the north part of Union county, however, deposition was uninterrupted, and there was laid down above the sandstone a thickness of 125 feet of Onondaga limestone.

The transition beds from the sandstone to the overlying limestone, and all of the limestone member, are well exposed in what is known as the Devil's Backbone and Bake-oven ridge, one-half mile to one mile north of Grand Tower. The contact of the Grand Tower limestone with the succeeding Hamilton beds may also be clearly seen in the Backbone bluff.

The strata in this region are all inclined to the eastward at an angle of about 24 degrees. This is due to the upthrow on the east side of a north-south fault plane that cuts the strata some distance further west, in Missouri.

Method of Work. In the detailed study of the strata of the Grand Tower formation, and effort was made to obtain as nearly as possible the entire fauna of the vorious rock layers, and also to determine the vertical range and relative aboundance of the different species of fossils. To this end the exposed rock ledges were arbitraril divided into zones from six inches to only a few feet in thickness. The fossils from each of these layers of zones were kept separate, in order that the range and the relations of the successive faunules might be ascertained. This method of work has made it possible to determine the species of fossils that are distinctive respectively of the various horizons of the formation, and has furnished much information concerning the fauna that could be obtained in no other way.

Detailed Sections. There are given below detailed sections of the Grand Tower strata exposed in Illinois, accompained by lists of fossils that were collected from the successive horizons. In these lists the relative abundance of each species is indicated by the suffix r (=rare), c (=common), or a (=abundant) after the name.

Section of the basal portion of the Grand Tower formation exposed along a small stream in the northwest quarter of sec-

Fig. 7. Exposure of Grand Tower limestone in the back-bone ridge, one-half mile north of Grand Tower, in Jackson county, Illinois.

Fig. 8. Upper portion of Grand Tower limestone showing massive character of the layers, and eastward dip of the strata. Contact of Grand Tower and Hamilton exposed near the top.

tion 26, Jonesboro township (T. 12 S., R. 2 W.) in Union county. The section is designated S. 60, and the sequence is from the bottom upward.

S 60 a. Bed of gray to yellow chert in layers four to nine inches thick (Clear Creek formation) .....9 feet.
S 60 b. Reddish-brown, rather friable sandstone (Grand Tower formation).. .. ..2 feet.
S 60 c. Gray chert in layers three to eight inches thick, containing numerous Clear Creek fossils .....1 foot, 6 in.
S 60 d. Reddish-brown, friable sandstone, in layers ten to eighteen inches thick (Grand Tower formation) .....2 feet, 10 inches

Michelinia stylopora a,
Amphigenia curta r,
Meristella cf. *lentiformis* r,
Pentamerella cf. *arata* r,
Spirifer duodenarius r,
Spirifer cf. *granulosus* c.

S 60 e. Layers of gray chert, three to nine inches thick, containing numerous fossils characteristic of the Clear Creek formation .....
..... 5 feet, 7 inches
S 60 f. Reddish-brown, rather soft sandstone, containing many fossils .. ..6 feet, 8 inches

Favosites hemisphericus? c,
Michelinia stylopora a,
Zaphrentis exigua c,
Zaphrentis cf. *nitida* c,
Zaphrentis cf. *recta* c,
Zaphrentis ungula c.
Amphigenia curta r,
Leptostrophia perplana r,
Meristella cf. *lentiformis* r,
Nucleospira cf. *elegans* r,
Spirifer sp. c,
Tentaculites elongatus r.

The interwedging of the upper layers of the Clear Creek cherts with the lower layers of the succeeding sandstone of Onondaga age, as shown in the foregoing section, indicates that the Onondaga deposits follow the cherts without any break in sedimentation, and that the Clear Creek formation in Illinois represents deposits of Upper Oriskany time.

A sandstone ledge, eleven feet in thickness, representing a horizon slightly higher than the preceding, is exposed in the southeast quarter of section 34, T. 11 S., R. 2 W. From this outcrop the following fossils were obtained:

Aulacophyllum trisulcatum? r,
Favosites sp. undt, r,
Michelinia stylopora c,
Zaphrentis exigua c,
Zaphrentis nitida? c,
Zaphrentis recta c,
Zaphrentis ungula c,
Athyris vittata r,
Centronella glansfagea r,
Leptaena rhomboidalis r,
Leptostrophia perplana a,
Meristella cf. *lentiformis* c,
Rhipidomella cf. *musculosa* c,
Rhipidomella vanuxemi r,
Schuchertella chemungensis arctistriata r,
Spirifer duodenarius c,
Spirifer sp. c,
Spirifer cf. *macrothyris* r,
Stropheodonta demissa c,
Conocardium cuneus var. c,
Odontocephalus arenarius c,
Phacops cristata c,
Proetus crassimarginatus c,
Proetus marginalis c,
Proetus cf. *tolliceps* c,
Proetus sp. r

The names of the fossils collected from this sandstone are prefixed by a star in the general table of fossils from the Grand Tower formation, given on a later page.

The following is a section of the Grand Tower strata excellently exposed in the Backbone-Bake-oven ridge, a short distance north of the town of Grand Tower. The lower part was made from the north and west sides of the Bake-oven bluff, while the middle and upper portions were taken from the west face of the Backbone ridge, one-half mile further south. The section bears the field number S 56, and begins with "a" at the bottom. The total thickness of strata exposed here is about 129 feet.

S 56 a. Bed of coarse grained, gray, crystalline limestone, in layers six to eighteen inches thick, somewhat arenaceous in the lower part. To the level of the water in the river .....8 feet.

Dendropora neglecta r,
Amboccelia umbonata r,
Atrypa reticularis r,
Camarotoechia cf. *carolina* c,
Centronella glansfagea r,
Chonetes mucronatus r,
Dalmanella sp. r,
Leptaena rhomboidalis c,
Leptostrophia perplana r,
Meristella cf. *lenta* c,
Nucleospira concinna c,
Nucleospira ventricosa r,
Pholidops hamiltonae r,
Productella sp. r,
Rhipidomella cf. *musculosa* r,
Rhipidomella livia c,
Rhipidomella sp. r,
Schizophoria propinqua r,
Spirifer cf. *disparilis* r,
Spirifer duodenarius r,
Spirifer macrothyris c,
Spirifer macrus r,
Stropheodonta concava c,
Stropheodonta demissa r,
Strophonella ampla c,
Platyceras carinatum r,
Platyceras erectum c,
Platyceras dumosum r,
Platyostoma sp. r.

S 56 b. Alternating and somewhat mixed layers of gray, crystalline limestone, and of rather coarse grained sandstone, the sandstone element somewhat predominating .....7 feet, 6 inches.

Coscinium cribriforme r,
Atrypa reticularis c,
Centronella glansfagea c,
Charionella scitula r,
Chonetes mucronatus r,
Dalmanella lenticularis r,
Eatonia? sp. r,
Leptaena rhomboidalis c,
Meristella lenta c,
Rhipidomella vanuxemi c,
Spirifer duodenarius c,
Spirifer intermedius r,
Spirifer macrothyris r,
Spirifer macrus r,
Stropheodonta sp. r.
Strophonella ampla r,
Tentaculites scalariformis r,
Platyceras carinatum r,
Platyceras erectum c.

S 56 c. Bed of gray, granular, sub-crystalline limestone, fossils most abundant in the lower part, an iron stained zone present at the top .....4 feet.

Coscinium cribriforme r,
Atrypa reticularis c,
Centronella glansfagea r,
Chonetes mucronatus r,
Eatonia whitfieldi? r,
Leptostrophia perplana r,
Rhipidomella vanuxemi c,
Spirifer duodenarius c,
Spirifer intermedius r,
Spirifer macrothyris c,
Spirifer macrus r,
Spirifer cf. *varicosus* r,
Stropheodonta inaequiradiata r,
Strophonella ampla c,
Igoceras conicum r,
Platyceras erectum c,
Platyceras carinatum r,
Platyceras thetis r,
Platyostoma lineata r,
Dalmanites sp. c,
Odontocephalus aegeria a,
Proetus sp. r,

S 56 d. Gray, crystalline limestone, in imperfect layers fourteen to twenty-four inches thick. Trilobite remains most abundant in the middle and upper parts .....14 feet.

Atrypa reticularis r,
Centronella glansfagea c,
Leptaena rhomboidalis c,
Pentamerella arata? r,
Rhipidomella sp. r,
Spirifer duodenarius r,
Spirifer macrothyris c,
Spirifer macrus r,
Spirifer cf. *segmentus* r,
Spirifer varicosus r,
Dalmanites calypso c,
Odontocephalus aegeria a,
Phacops sp. r.

S 56 e. Gray, granular to sub-crystalline limestone, in layers six to eleven inches thick. Fossils imperfectly preserved .....6 feet.

Anoplia nucleata? r,
Camarotoechia carolina c,
Centronella glansfagea c,
Leptaena rhomboidalis r,
Meristella cf. *nasuta* c,
Spirifer duodenarius r,
Spirifer macrothyris c,
Platyceras dumosum r,
Platyceras sp. r.

S 56 f. Gray, sub-crystalline limestone, with a two-inch band of much broken fossils at the base .....5 feet, 2 inches.

Atrypa reticularis c,
Camarotoechia carolina c,
Centronella glansfagea c,
Leptaena rhomboidalis r,
Rhipidomella vanuxemi c,
Schizophoria propinqua r,
Spirifer sp. r,
Spirifer macrothyris c,
Platyceras sp. r,
Dalmanites sp. c,
Odontocephalus aegeria c,
Fish remains c,

S 56 g. Light gray, sub-crystalline limestone, in layers ten to twenty-four inches thick. A three-foot barren zone near the middle, and a trilobite zone near the top .....5 feet, 4 inches.

Camarotoechia carolina c,
Camarotoechia tethys r,
Centronella glansfagea c,
Charionella scitula r,
Cyrtina hamiltonensis r,
Leptaena rhomboidalis r,
Rhipidomella vanuxemi r,
Schizophoria propinqua c,
Spirifer duodenarius r,
Spirifer varicosus c,
Platyceras dumosum r,
Odontocephalus aegeria c.

S 56 h. Layer of light gray, sub-crystalline limestone ..3 feet, 2 in.

Cystiphyllum americanum r,
Dolatocrinus sp. r,
Nucleocrinus sp. r,
Athyris vittata c,
Atrypa aspera r,
Atrypa reticularis a,
Camarotoechia carolina c,
Centronella glansfagea a,
Charionella scitula r,
Chonetes mucronatus r,
Craniella hamiltonae r,
Cyrtina hamiltonensis c,
Eunella sp. r,
Leptaena rhomboidalis r,
Meristella sp. r,
Nucleospira ventricosa c,
Pentamerella arata? r,
Pholidops hamiltonae r,
Pholidostrophia iowensis r,
Productella spinulicosta r,
Reticularia fimbriata c,
Rhipidomella vanuxemi a,
Cf. *Rhynchonella* sp. c,
Schizophoria propinqua c,
Schuchertella cf. *pandora* r,
Spirifer duodenarius a,
Spirifer varicosus c,
Stropheodonta concava r,
Stropheodonta demissa r,
Stropheodonta inaequistriata c,
Stropheodonta patersoni r,
Stropheodonta sp. r,
Actinopteria sp. r,
Aviculopecten terminalis r,
Orthonychia dentalia r,
Platyceras blatchleyi c,
Platyceras carinatum r,
Platyceras dumosum c,
Platyceras erectum r,
Platyceras subrectum r,
Platyostoma turbinata cochleata r,
Dalmanites cf. *calypso* r,
Dalmanites sp. r,
Odontocephalus aegeria r,
Proetus cf. *clarus* r.

S 56 i. Impure, dark colored, fine-grained limestone, in imperfect layers nine to twenty-three inches thick. A band containing numerous shells of a small Chonetes occurs about twenty inches below the top .....7 feet, 9 inches.

Heliophyllum sp. r,
Atrypa reticularis c,
Atrypa spinosa r,
Chonetes cf. *pusillus* a,
Craniella hamiltonae r,
Leptostrophia perplana r,
Pentamerella arata r,
Pholidops hamiltonae r,
Pholidostrophia iowensis a,
Productella spinulicosta r,
Reticularia fimbriata r,
Reticularia fimbriata var. r,
Rhipidomella vanuxemi a,
Schizophoria propinqua a,
Schuchertella chemungensis pectinacea r,
Spirifer sp. r,
Schuchertella chemungensis perversa r,
Spirifer duodenarius r,
Spirifer cf. *grieri* r,
Spirifer varicosus c,
Strophalosia truncata r,
Stropheodonta concava c,
Stropheodonta crebristriata r,
Stropheodonta inaequistriata r,
Stropheodonta patersoni c,
Cf. *Aviculopecten ignotus* r,
Callonema lichas r,
Loxonema terebrum r,
Platyceras blatchleyi c,
Platyceras carinatum r,
Platyostoma lineata r,
Gomphoceras sp. r,
Phacops sp. a.

S 56 j. Impure, gray limestone, with few fossils ....3 feet, 4 inches.

Camarotoechia carolina r,
Spirifer cf. *intermedius* r,

S 56 k. Dark colored, impure limestone, in imperfect layers four to ten inches thick .....2 feet, 3 inches.

Atrypa reticularis a,
Camarotoechia carolina c,
Chonetes mucronatus a,
Cyrtina hamiltonensis c,
Leptostrophia perplana c,
Nucleospira concinna c,
Pholidostrophia iowensis a,
Productella spinulicosta r,
Rhipidomella vanuxemi c,
Schizophoria propinqua a,
Schuchertella chemungensis arctistriata c,
c,
Spirifer duodenarius r,
Spirifer raricostus r,
Spirifer varicosus c,
Spirifer sp. r,
Stropheodonta concava a,
Stropheodonta inaequistriata c,
Stropheodonta inaequistriata var. a,
Stropheodonta patersoni a,
Strophonella ampla r,
Aviculopecten sp. r,
Aviculopecten terminalis r,
Conocardium cuneus var. r,
Bellerophon sp. r,
Callonema lichas r,
Euomphalus decewi r,
Murchisonia sp. r,
Orthonychia dentalia r,
Platyceras carinatum r,
Dalmanites sp. r

S 56 l. Bed of impure limestone, in layers eight to twelve inches thick .....1 foot, 8 inches.

Atrypa aspera r,
Atrypa reticularis r,
Camarotoechia horsfordi c,
Chonetes lineatus c,
Chonetes yandellanus r,
Leptostrophia perplana c,
Meristella rostrata r,
Productella spinulicosta r,
Rhipidomella vanuxemi c,
Stropheodonta cf. *callosa* r,
Stropheodonta concava r,
Stropheodonta inaequistriata var. r,
Schizophoria propinqua c,
Spirifer sp. r,
Spirifer varicosus c,
Platyceras carinatum r,
Phacops cristata r,

S 56 m. Layer of dark gray, impure limestone .....10 inches.

Atrypa aspera r,
Atrypa reticularis c,
Camarotoechia carolina c,
Chonetes yandellanus c,
Leptostrophia perplana a,
Productella spinulicosta c,
Rhipidomella vanuxemi c,
Schizophoria propinqua r,
Spirifer acuminatus? r,
Stropheodonta concava r,
Stropheodonta demissa r,
Stropheodonta inaequiradiata r,
Tentaculites scalariformis c,
Aviculopecten exaculus r,
Schizodus sp. r,
Orthonychia dentalis r,
Platyceras sp. r,
Platyceras carinatum r,
Phacops cristata c,
Proetus sp. r,
Onychodus sigmoides r

S 56 n. Bed of dark gray to drab limestone, in imperfect layers three to eight inches thick, with intercalated thin bands of chert .....3 feet, 6 inches.

Amplexus yandelli r,
Dendropora cf. *elegantula* r,
Nucleocrinus sp. r,
Nucleocrinus verneuili r,
Cystodictya gilberti r,
Fenestella stellata r,
Orthopora sp. r,
Polypora cf. *quadrangularis* r,
Semicoscinium sp. r,
Ambocoelia umbonata r,
Athyris vittata c,
Atrypa aspera c,
Atrypa reticularis a,
**Camarophoria gainesi* c,
Camarotoechia carolina c,
Camarotoechia sappho c,
Charionella scitula c,
Chonetes mucronatus c,
Chonetes yandellanus r,
Crania crenistriata r,
Craniella hamiltonae r,
Cyrtina hamiltonensis c,
Leptaena rhomboidalis r,
Leptostrophia perplana a,
Orbiculoidea ampla r,
Pentamerella papilionensis r,
Pholidops hamiltonae r,
Pholidostrophia iowensis r,
Productella spinulicosta a,
Rhipidomella vanuxemi c,
Rhynchonella cf. *louisvillensis* r,
Roemerella sp. r,
Schizophoria propinqua c,
Schuchertella chemungensis perversa r,
Spirifer sp. r,
Spirifer macrus r,
Spirifer varicosus r,
Stropheodonta concava c,
Stropheodonta inaequistriata r,
Stropheodonta inaequistriata var. c,
Stropheodonta inaequiradiata r,
Stropheodonta patersoni c,
Aviculopecten sp. c,
Aviculopecten sp. c,
Aviculopecten exaculus r,
Aviculopecten terminalis r,
Cf. *Actinopteria boydi* c,
Glyptodesma occidentalis r,
Cypricardinia indenta r,
Modiomorpha linguiformis r,
Cf. *Pterinopecten multiradiatus* r,
Igoceras conicum c,
Murchisonia sp. r,
Platyceras blatchleyi c,
Platyceras carinatum r,
Platyceras dumosum r,
Strophostylus varians r,
Gomphoceras sp. r,
Dalmanites calypso r,
Phacops rana c,
Proetus clarus r,
Proetus sp. r.

*This species was described by Nettelroth as *Rhynchonella gainesi*, but it possesses a spoon-shaped spondylium as in Camarophoria.

S 56 o. Bed of hard, grayish-brown limestone, in imperfect layers which on weathering appear to be three to twelve inches thick. Fossils most abundant in a two-foot zone near the middle..22 feet, 6 inches.

Atrypa reticularis r,
Camarotoechia carolina c,
Camarotoechia horsfordi c,
Camarotoechia tethys c,
Chonetes yandellanus a,
Leptostrophia perplana r,
Pholidops hamiltonae r,
Pholidostrophia iowensis r,
Productella spinulicosta r,
Spirifer macrus? c,
Spirifer varicosus c,
Stropheodonta concava r,
Stropheodonta demissa c,
Tentaculites scalariformis a,
Paracyclas elliptica r,
Platyceras blatchleyi r,
Platyceras carinatum r,
Platyceras erectum r,
Proetus sp. r,

S 56 p. Dark colored, impure limestone, in layers three to ten inches thick. Shells of large Stropheodonta near the middle..3 ft., 6 in.

Atrypa reticularis c,
Camarophoria gainesi r,
Chonetes mucronatus a,
Leptaena rhomboidalis c,
Leptostrophia perplana r,
Lingulodiscina? sp. r,
Pholidostrophia iowensis r,
Productella spinulicosta r,
Rhipidomella vanuxemi c,
Schizophoria propinqua r,
Spirifer acuminatus r,
Spirifer sp. r,
Spirifer varicosus r,
Stropheodonta concava c,
Stropheodonta demissa r,
Stropheodonta patersoni r,
Stropheodonta inaequistriata r,
Tentaculites scalariformis r,
Gomphoceras sp. r

S 56 q. Dark gray, somewhat shaly limestone, in layers six to eleven inches thick .....2 feet, 8 inches.

Camarophoria gainesi r,
Chonetes yandellanus c,
Pholidostrophia iowensis r,
Productella spinulicosta a,
Rhipidomella livia r,
Schizophoria propinqua r,
Spirifer cf. *segmentus* r,
Spirifer gregarius var. r,
Strophalosia truncata r,
Paracyclas elliptica c,
Gomphoceras sp. r

S 56 r. Gray to dark drab, somewhat shaly limestone, in layers two to eight inches thick .....6 feet.

Camarotoechia horsfordi r,
Chonetes konickianus c,
Chonetes yandellanus c,
Productella spinulicosta r,
Rhipidomella livia c,
Spirifer varicosus c,
Strophalosia truncata r,
Stropheodonta concava r,
Paracyclas elliptica r.

S 56 s. Gray limestone, in rather thick, imperfectly separating layers, composed largely of shells of Chonetes .....1 foot, 7 inches.

Chonetes yandellanus a,
Pholidostrophia iowensis r,
Spirifer gregarius var. r,
Spirifer sp. r,
Aviculopecten terminalis r,
Paracyclas elliptica r,
Gomphoceras sp. r.

S 56 t. Dark colored, impure limestone, composed largely of shells of Chonetes .....1 foot, 2 inches

Chonetes konickianus c,
Chonetes yandellanus a,
Productella spinulicosta r,
Paracyclas elliptica r.

S 56 u. Gray to dark colored, somewhat shaly limestone....2 feet.

Atrypa aspera c,
Camarotoechia horsfordi c,
Chonetes yandellanus a,
Cyrtina hamiltonensis r,
Leptostrophia perplana r,
Pholidostrophia iowensis c,
Productella spinulicosta r,
Schizophoria propinqua c,
Spirifer gregarius var. r,
Spirifer perextensus c,
Spirifer varicosus c,
Strophalosia truncata r,
Stropheodonta concava c,
Stropheodonta inaequistriata r,
Paracyclas elliptica c,
Bellerophon pelops r.

S 56 v. Gray, impure limestone .....2 feet, 3 inches.

Nucleocrinus sp. r,
Atrypa reticularis r,
Atrypa aspera r,
Chonetes pusillus c,
Leptostrophia perplana r,
Pholidostrophia iowensis c,
Rhipidomella penelope r,
Rhipidomella vanuxemi c,
Rhipidomella sp. r,
Spirifer perextensus r,
Spirifer varicosus c,
Strophalosia truncata c,
Stropheodonta concava r,
Paracyclas elliptica r.

S. 56 w. Hard, gray to drab limestone .....1 foot, 8 inches.

Atrypa reticularis r,
Chonetes yandellanus r,
Nucleospira concinna r,
Pholidostrophia iowensis c,
Productella spinulicosta a,
Schizophoria propinqua r,
Schuchertella chemungensis arctistriata c,
Spirifer sp. r,
Spirifer varicosus r,
Strophalosia truncata a,
Paracyclas elliptica c,
Gyroceras sp. r.

S 56 x. Hard, dark gray limestone, with many small nodules of chert in the upper three feet, and a zone of Chonetes eight inches below the chert .....5 feet, 6 inches.

Chonetes konickianus c,
Pholidostrophia iowensis c,
Productella spinulicosta r,
Spirifer gregarius var. r,
Phacops rana r,
Tentaculites scalariformis r

S 56 y. Massive ledge of hard, gray, sub-crystalline limestone ....7 feet, 6 inches.

Cyathophyllum rugosum c,
Favosites emmonsi c,
Cystodictya meeki r,
Chonetes konickianus c,
Chonetes yandellanus c,
Cyrtina hamiltonensis c,
Eunella sullivanti r,
Pholidostrophia iowensis a,
Productella spinulicosta a,
Cf. *Camarophoria gainesi* (young) r,
Spirifer gregarius r,
Spirifer gregarius var. a,
Spirifer segmentus c,
Strophalosia truncata r,
Stropheodonta concava c,
Leptodesma sp. r,
Loxonema sp. r,
Bellerophon pelops r,
Platyceras blatchleyi r

Immediately above S 56 y the lithology changes abruptly from massive, subcrystalline limestone below, to thinner bedded, more argillaceous material above. Above this member the characteristic Onondaga fossils *Cyathophyllum rugosum, Chonetes konickianus, C. yandellanus, Eunella sullivanti, Spirifer gregarius,* and its variety, *S. segmentus, Bellerophon pelops* and *Platyceras blatchleyi* have disappeared. In their places such Hamilton species as *Microcyclus discus, Chonetes pusillus, Eunella attenuata, Spirifer fornacula, S. divaricatus* and *Actinopteria boydi* become the conspicuous froms.

There is given in tabular form below a list of the fossils collected from the Grand Tower formation in Illinois. In this table the species having a star prefixed to their names, occur in the sandstone member at the base. In column No. 1, on the right, there are indicated by a cross those species occurring in the Grand Tower strata, below the horizon of S. 56 h of the major section, which have also been reported by Kindle[1] from the Jeffersonville beds of Indiana. In column No. 2 there are shown by a cross those Jeffersonville species which are

[1]Kindle: Devonian Fossils and Stratigraphy of Indiana. 25th Ann. Rept. Geol. and Nat. Hist. of Ind., 1900.

also found in the Grand Tower limestone above the base of S 56 h of the major section. In the third column, crosses indicate those of the Grand Tower species that have been reported from the Onondaga strata of New York[2]. Those species that were also present in the underlying Oriskany (Clear Creek) strata of this region are indicated in the table by the word Oriskany after their names.

General Table of Fossils of the Grand Tower Formation.

	1	2	3
Amplexus yandelli Ed. and Haime			
**Aulacophyllum trisulcatum* Hall			
Cyathophyllum rugosum Hall		x	x
Cystiphyllum americanum Ed. and Haime		x	x
Dendropora cf. *elegantula* Davis			
Dendropora neglecta Rominger			
Favosites emmonsi Rominger		x	
**Favosites* cf. *hemispherica* Troost			
Heliophyllum sp.			
**Michelinia stylopora* Eaton (Oriskany)			
**Zaphrentis exigua* (Billings)			
**Zaphrentis nitida* Hall?			
**Zaphrentis recta* Meek			
**Zaphrentis ungula* Rominger			
Dolatocrinus sp.			
Nucleocrinus verneuili Troost		x	x
Nucleocrinus sp.			
Coscinium cribriforme Prout			
Cystodictya gilberti (Meek)			
Cystodictya meeki (Nicholson)			
Fenestella stellata Hall			
Orthopora sp.			
Polypora cf. *quadrangularis* Hall			
Semicoscinium sp.			
Ambocoelia umbonata Conrad	x	x	x
**Amphigenia curta* Meek and Worthen (Oriskany)			
Anoplia cf. *nucleata* Hall (Oriskany)			
Athyris vittata Hall	x	x	
Atrypa aspera Hall			x
**Atrypa reticularis* (Linn) (Oriskany)	x	x	x
Atrypa spinosa Hall			x
Camarophoria gainesi (Nettelroth)		x	
**Camarotoechia carolina* Hall (Oriskany?)	x	a	
Camarotoechia horsfordi Hall			
Camarotoechia sappho Hall		x	
Camarotoechia tethys (Billings)		x	x
**Centronella glansfagea* Hall (Oriskany)			x
Charionella scitula Hall (Oriskany)			x
Chonetes konickianus N. and P.			
Chonetes lineatus (Conrad)			x
Chonetes mucronatus Hall (Oriskany)	x	x	x
Chonetes pusillus Hall			
Chonetes yandellanus Hall			
Crania crenistriata Hall		x	x
Craniella hamiltonae Hall	x	x	
Cryptonella sp.			
Cyrtina hamiltonensis Hall		x	x
Dalmanella lenticularis (Vanuxem)			x
Dalmanella sp.			
Eatonia cf. *whitfieldi* Hall (Oriskany?)			
Eunella sp.			
Eunella sullivanti Hall		x	

[2]Hall: Paleontology of New York. Vol. IV, 1867.

General Table of Fossils of the Grand Tower Formation—*Continued.*

	1	2	3
**Leptaena rhomboidalis* (Wilckens) (Oriskany)	x	x	x
**Leptostrophia perplana* (Conrad) (Oriskany)	x	x	x
Leptostrophia perplana var,			
Lingulodiscina sp.			
Meristella lenta Hall			
**Meristella* cf. *lentiformis* Clarke (Oriskany)			
Meristella cf. *nasuta* (Conrad)	x		x
Meristella rostrata Hall			
Nucleospira concinna Hall (Oriskany)	x	x	x
**Nucleospira* cf. *elegans* Hall			
Orbiculoidea ampla Hall			
Reticularia fimbriata (Conrad)		x	x
**Pentamerella arata* (Conrad)	x	x	x
Pentamerella papilionensis Hall		x	
Pholidops hamiltonae Hall			
**Pholidops oblata* Hall			
Pholidostrophia iowensis (Owen)		x	x
Productella spinulicosta Hall		x	x
Productella sp.			
Reticularia fimbriata (Conrad)		x	x
Reticularia fimbriata var.			
Rhipidomella livia (Billings)			x
**Rhipidomella musculosa* Hall (Oriskany)			
Rhipidomella penelope Hall			
**Rhipidomella vanuxemi* Hall	x	x	x
Rhynchonella cf. *louisvillensis* Nettelroth			
Rhynchonella sp.			
Roemerella sp.			
Schizophoria propinqua Hall (Oriskany?)	x	x	x
**Schuchertella chemungensis arctistriata* Hall	x	x	
Schuchertella chemungensis pectinacea Hall			x
Schuchertella chemungensis perversa Hall			
Schuchertella pandora (Billings) (Oriskany)			x
Spirifer acuminatus (Conrad)		x	x
Spirifer disparilis Hall			x
**Spirifer duodenarius* Hall			x
Spirifer sp.			
Spirifer gregarius Hall		x	x
Spirifer gregarius var.			
Spirifer grieri Hall		x	x
Spirifer intermedius Hall			
**Spirifer macrothyris* Hall (Oriskany?)			x
Spirifer macrus Hall			x
Spirifer perextensus M. and W.			
Spirifer raricostus Conrad (Oriskany)		x	x
Spirifer segmentus Hall	x	x	
Spirifer varicosus Hall	x	x	x
Strophalosia truncata (Hall)			
**Stropheodonta callosa* Hall			x
Stropheodonta concava Hall	x	x	x
Stropheodonta crebristriata Hall			x
**Stropheodonta demissa* (Conrad)	x	x	x
Stropheodonta inaequiradiata Hall			x
Stropheodonta inaequistriata (Conrad)		x	x
Stropheodonta inaequistriata var.			
Stropheodonta patersoni Hall			x
Strophonella ampla Hall			x
**Tentaculites elongatus* Hall (Oriskany)			
Tentaculites scalariformis Hall	x	x	x
Actinopteria sp.			
Cf. *Actinopteria boydi* (Conrad)		x	
Aviculopecten exacutus Hall		x	
Cf. *Aviculopecten ignotus* Hall			x
Aviculopecten terminalis Hall		x	x
Aviculopecten sp.			
**Conocardium cuneus* var.	x	x	
Cypricardinia indenta Conrad		x	
Glyptodesma occidentale Hall			
Leptodesma sp.			

General Table of Fossils of the Grand Tower Formation—*Continued.*

	1	2	3
**Megambonia* cf. *cardiiformis* Hall			
Modiomorpha linguiformis Hall			
Paracyclas elliptica Hall		x	x
Cf. *Pterinopecten multiradiatus* Hall			x
Schizodus sp.			
Bellerophon sp.			
Bellerophon pelops Hall		x	x
Callonema lichas Hall		x	x
Euomphalus decewi Billings		x	x
Igoceras conicum Hall (Oriskany)			
Loxonema sp.			
Loxonema terebra White			
Murchisonia sp.			
Orthonychia dentalia Hall	x	x	x
Platyceras blatchleyi Kindle		x	
Platyceras carinatum Hall	x	x	x
**Platyceras dumosum* Conrad			x
Platyceras erectum Hall			x
Platyceras subrectum Hall			x
Platyceras thetis Hall			x
Platyostoma lineata Conrad			x
Platyostoma turbinata cochleata Hall			x
Strophostylus varians Hall		x	x
Gomphoceras sp.			
Gomphoceras sp.			
Gyroceras sp.			
Dalmanites calypso Hall			x
Dalmanites sp.			
Odontocephalus aegeria Hall	x	x	x
Odontocephalus arenarius Meek (Oriskany?)			
**Phacops cristata* Hall (Oriskany)	x	x	x
Phacops rana Green		x	
Proetus clarus Hall		x	x
**Proetus crassimarginatus* Hall			x
**Proetus* cf. *folliceps* Hall			
**Proetus marginalis* Conrad			
**Proetus rowii* Green			
**Proetus* sp. (Oriskany)			
Onychodus sigmoides Newberry			

Both the Grand Tower formation in Illinois, and the Jeffersonville beds in Indiana, have been considered a western extension of the Onondaga strata of New York.

A total of 162 species of fossils were collected from the Grand Tower formation in Illinois, 142 species exclusive of the corals and bryozoa. Kindle lists 158 species from the Jeffersonville beds of Indiana. Out of this almost equal number of species from the respective areas, only 55, or 34 per cent, are common to the strata in the two localities. Of the Grand Tower fossils in the above table, 70 species, or 49 per cent, occur also in the Onondaga beds of New York. The resemblance of the fauna of the Grand Tower formation is thus shown to be closer with that of the Onondaga strata of New York than with that of the Jeffersonville beds of Indiana.

The thickness of the Jeffersonville limestone in Indiana is very much less than either that of the Grand Tower formation in Illinois, or of the Onondaga limestone in New York. Moreover, it is in New York and in Illinois that the transition from the Oriskany to the Onondaga is complete, no trace of Oriskany strata occurring in Indiana.

From the foregoing table, it may be seen that all of the identified species of fossils of the Grand Tower formation that occur also in the Jeffersonville beds of Indiana appear in the Grand Tower section above the base of the horizon S. 56 h (about the middle part). A number of the Jeffersonville species appear below that horizon, but all of these are forms that have a considerable vertical range and are present also in the beds above S. 56 h, as shown in columns 1 and 2 of the table. With the exception of the single species, *Odontocephalus aegeria,* that appears for the last time in S 56 h, not a single one of the diagnostic fossils of the lower 75 feet (practically the lower half) of the Grand Tower strata, occurs in the Jeffersonville limestone of Indiana. From these facts it is concluded that no strata corresponding with the lower half of the Grand Tower formation are present in Indiana; and that the Jeffersonville limestone represents deposition during only the latter half of Onondaga time.

Evidence Bearing on the Source of the Onondaga Fauna. Concerning the origin of the Onondaga fauna, Weller[1] has suggested that, "From the geographic distribution, it may have originated somewhere in the Arctic regions; and that representatives of it migrated southward, both into North America and into Europe. The typical Niagaran fauna, as it is found in the Appalachian province, is thought to have come into the region from the north through the junction of the Hudson's Bay basin with the interior basin, and, when it withdrew from the interior, it doubtless followed the same route by which it had entered. During the period of readjustment between Silurian and Devonian time it is not im-

1 Weller. Journal of Geology. Vol. X, p. 429, 1902.

probable that the restricted Niagaran fauna became isolated in the Arctic region, and that from the elements of this fauna during a long period of time, the Onondaga fauna was evolved; and that this modified fauna once more entered the interior basin from the north when the Onondaga seas overspread this region."

The fact that corals and cephalopods were conspicuous elements of the Niagaran fauna, and that representatives of these classes, changed to be sure from their Silurian ancestors, are important elements in the Onondaga fauna of Ontario, New York, Ohio and Indiana supports this view. The distribution of the fish remains of this time also favor such an origin.

Schuchert[2] has suggested that the Onondaga fauna entered the interior basin of North America from the south. He bases his view on the great abundance of corals in the Onondaga strata of Ohio and Indiana. Since reef building corals of the present are limited to warm seas, he assumes that this is a warm water fauna, and that its source was in southern waters.

The evidence furnished by the sequence of fossils in the Grand Tower section is interpreted as indicating that the Onondaga fauna reached the interior of North America from two different sources. The fact that deposition was continuous in southern Illinois from the upper Oriskany into the Onondaga shows that early Onondaga sediments are present in the Illinois region. It is to be noticed that the great Onondaga coral development that occurred in Indiana and Ohio was not present in southwestern Illinois. Some of the characteristic coral species, as *Cyathophyllum rugosum* and *Favosites emmonsi*, are not rare in the Grand Tower section, but they appear only in the upper part. The fact that the greater portion of the Grand Tower strata are quite pure limestones shows that it was not the muddy condition of the seas that barred the corals from this region. It is not probable either that the greater coldness of the water here was an inhibiting factor.

It may be seen from the table that a few corals were present

2 Schuchert. Bull. Geol. Soc. of America, Vol. XX, p. 401.

in the Illinois basin during the time of deposition of the lowest of the Grand Tower strata. Of these forms *Michelinia stylopora* and a species of *Zaphrentis* occurred in the underlying Oriskany (Clear Creek) beds. Out of twenty-eight species of fossils associated with the corals in these lower sandstone layers, thirteen, or nearly 47 per cent, were present in the Upper Oriskany (Clear Creek) strata of Illinois. Seven out of these thirteen species have not been reported from the Jeffersonville limestone, while the other six are forms having a wide distribution. Of the remaining fifteen species from the sandstone layers, ten are not reported by Kindle from the Jeffersonville beds of Indiana. The other five forms have a considerable vertical, and a wide geographical, range.

The small number of these coral species in the lower Grand Tower strata, and the absence of the greater number (60 per cent) of their associates from the Indiana area, would preclude the assumption that the Jeffersonville limestone fauna could have been derived from this source.

It may also be seen from the faunal lists in the foregoing section that the cephalopod element in the fauna is limited to the upper portion of the Grand Tower beds, although in New York the cephalopods become conspicuous in the early Onondaga strata; also that the characteristic Onondaga fish fauna of Ohio never reached this Illinois basin.

From the above considerations it is assumed that one arm of the Onondaga sea advanced on the continent from the south, as in the preceding Oriskany time, reaching as far north as Jackson county, Illinois. Other sea incursions are thought to have come in from the north and east, bringing the corals and the cephalopods into the interior of the continent. This northern interior sea is thought to have been separated by a land barrier from the southern basin in which the Grand Tower limestone was deposited, until the middle of Onondaga time. Not until near this same time is it thought that the northern sea, bringing the Jeffersonville fauna, extended as far south as southern Indiana. Not until somewhat later still was the barrier which separated the northern and southern

basins entirely submerged, so that the cephalopods and corals of the northern province were permitted to spread into this southern sea embayment, and the general Onondaga fauna was able to migrate freely from north to south across the eastern interior portion of the continent.

J. A. Udden presented a paper of which the following is an abstract.

OBSERVATIONS ON THE EARTHQUAKE IN THE UPPER MISSISSIPPI VALLEY, MAY 26, 1909.

Earthquakes are infrequent in this region, and notes on our seismic phenomena are the more desirable. This communication is based mostly on items gathered from forty weekly and ten daily newspapers published in the disturbed area, and includes observations made in more than one hundred different localities. These data are given below, referred to the several localities.*

The area sensibly disturbed by this earthquake extended over the greater part of Illinois, Iowa, Wisconsin, Michigan, Indiana, Missouri, and Minnesota, a region about eight hundred miles in diameter. The mesoseismal area appears to have been triangular in form and unusually large, the greatest violence having been noted near Platteville, in Wisconsin, and in Waukean and Bloomington, in Illinois, which places probably were separate epicenters. The velocity of the earthquake waves, calculated from the reported observations on time recorded by government observers in Peoria (8:38 A. M.) and in Washington, D. C. (8:41 A. M.), is 3.3 mile per second. While no great reliance can be placed on these figures, as the data are too few and their authenticity uninvestigated, yet the great size of the mesoseismal area is in harmony wih the velocity of the wave. Both indicate a great depth of focus. The highest seismic intensity was above seven of the Rossi-Forell scale.

The facts presented in the reports are sufficiently full to indicate approximately the position of the isoseismals. When these

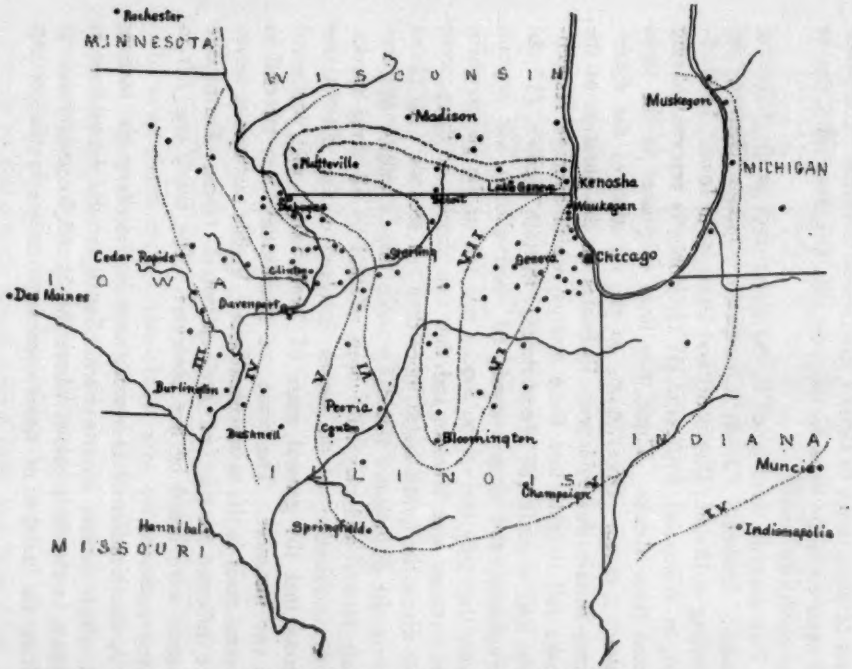


Fig. 9. Map of area disturbed by earthquake May 26, 1909.

are drawn on the basis of the intensities adopted in the Rossi-Forell scale, they run about as indicated on the accompanying map. It will be noticed that they center around one of the oldest lines of disturbance in Illinois, the LaSalle anticline. The parallel flexures in the lines on the west side are presumably due to the northwest center.

Two maxima were noted in the disturbance in the following places: Bushnell, Canton, Champaign, Chicago, Geneva, and Sterling in Illinois; Davenport and Dubuque in Iowa. In Madison, in Wisconsin, Professor W. H. Hobbs is reported having noted three shocks. These may have originated in the three epicentra noted. Observations on the duration of the disturbance sustain this evidence. Estimates on the duration of the quake fall roughly into three groups, which average respectively four seconds (28 observations), thirteen seconds (12 observations), and sixty seconds (6 observations). It appears likely that only one of the shocks was felt in the places where the duration was briefest, and that two shocks, or three, were felt where the quake lasted more than ten seconds. All places where the disturbance lasted for more than a minute are centraly located and may have been affected by all three shocks.

A classification of the senses involved in the observations shows that the general sense of "well being" was concerned in two instances. The sense of equilibrium was affected in several cases in the mesoseismal area. Visible earthquake waves are indicated for one of the epicentral tracts. Earthquake sounds were heard by five observers. The shock was *felt* in many instances.

A classification of the terms used in describing the manner in which various objects were affected by the disturbance is shown in the table below, where the figures in parenthesis indicate the number of times each term occurs in the reports.

Houses and buildings.	Dishes, bottles and tinware.	Ttables, beds, bookcases and stoves.	Windows and doors.
Shook (17)	Rattled (15)	Shook (8)	Rattled (12)
Rocked (7)	Were broken (8)	Were moved (6)	Shook (3)
Trembled (4)	Dashed to the floor (6)	Were overturned (3)	Were sprung (1)
Swayed (3)	Fell (3)	Swayed (2)	
Cracked (2)	Were shaken (3)	Quivered (2)	
Were jarred (2)	Were moved (2)	Trembled (2)	
Quivered (2)	Rocked (1)	Broke (1)	
Creaked (1)	Trembled (1)	Were upset (1)	
Heaved (1)	Wobbled (1)	Tipped over (1)	
	Was disturbed (1)	Rattled (1)	
		Rolled (1)	
		Rocked (1)	
		Heaved (1)	
		Had glass shattered (1)	

Lights and lamps.	Pictures and mirrors.	Chimneys.	Bric-a-brac.
Swayed (4)	Swung (3)	Fell (4)	Were shaken off (1)
Heaved (1)	Were shaken (3)	Toppled over (2)	Were thrown down (6)
Shook (1)	Were thrown (1)	Were razed (1)	Were tipped off (1)
Were shaken (1)	Tumbled (1)	Were shaken down (1)	Fell (1)
Were overturned (1)	Fell (1)	Cracked (1)	
Fell (1)	Jumped (1).		
Broke (1)			
Were knocked down (1)			
Were shaken out (1)			

In some places in the mesoseismal area the severity of the quake is reported as having frightened women, but no mention is made of fright among men. In a few cases fright was general. It would appear that this difference between the sexes in central inhibitory resistance is most evident in that belt where the intensity of the seismic waves was a little less than seven in the Rossi-Forell scale.

If the intensity of this earthquake had been only a little greater than it was, much damage to buildings would have resulted. Experience has shown that earthquakes are not fre-

quent in this part of the world, but we can not be certain that the late disturbance represents the greatest intensity of future earthquakes.

*NOTE.

The following observations were collected from daily and weekly newspapers published in the disturbed area, and from various personal communications. They are arranged by localities, in alphabetical order:

Aurora, Ill.—Chimneys fell, causing several fires.—A stove was overturned and started a fire.—Many chimneys fell.—Gas mains had connections loosened.—Some fires started the report "Aurora is burning."—Men were excited, women and children frightened.—People filled the streets.—The schools were closed.

Batavia, Ill.—A horse ran away, and the driver's leg broken.

Beloit, Wis.—Buildings were violently rocked.—Houses were jostled out of plumb.—People had difficulty in staying on their feet.

Benton Harbor, Mich.—Chinaware was broken.

Berwyn, Ill.—A vase with flowers was thrown from a mantle.—Dishes were broken.—A book was thrown down from a radiator.—Book cases were shaken.—A building swayed.

Bloomington, Ill.—Cracks were made in the brick walls of the jail. These were as wide as a man's hand.

Braidwood, Ill.—Vibrations were noted.

Burlington, Ia.—The taller buildings were shaken.—plates (dishes) were thrown down.—The shock was felt most in the upper stories of tall buildings.—Rumors of the shock caused people in neighboring towns to inquire about friends in the city over the telephone.—The shock frightened people who were in the upper stories of buildings.—There were perceptible tremors.

Cabery, Ill.—The earthquake was felt by everybody.

Cedar Rapids, Ia.—There was a slight shock.—The earthquake was felt by hundreds of people.—Buildings were slightly jarred.—Doors and dishes rattled.—There was a slight tremor.—Students in the Coe College building rushed down from the fourth floor.—The shock was by some attributed to explosions in a quarry.—Doors rattled in the Masonic library.—Many residents recognized the disturbance as an earthquake.

Chadwick, Ill.—Dishes and tinware rattled.

Champaign, Ill.—Buildings shook.

Chicago, Ill.—"Buildings standing on cassion foundations shook perceptibly, structures on old style floating piles were observed to sway." Benjamin H. Marshall, architect.—Western Union Gas and Electric Company had pipes broken, entailing a loss of several thousand dollars.—The balance of a rain gauge was displaced in the office of the U. S. Weather Bureau.—The earthquake was not felt on the ground floors of large buildings, but more generally in the upper stories.—Several chimneys were shaken down in the suburbs of Chicago.—Lighting fixtures were violently shaken in the federal building.—Office tables were moved in the federal building.—Ornaments were shaken from mantle pieces.—Dishes were broken.—Telephone wires swayed.—A

mirror swung on a wall.—Dishes rattled on a table.—Bric-a-brac fell from a mantle piece.—Telephones were put out of commission.—Heavy safes were jarred from their positions.—Wall decorations were thrown from their fastenings.—Drop lights swayed.—A bed was rolled back and forth, on its castors.—Electric light fixtures swayed alarmingly. —A receiver was knocked off from a telephone hook.—A glass shade on a gas light fell and broke.—Gas fixtures swayed.—A mirror oscillated.—The shock caused some people to run on the streets.—Some Italians, recalling the earthquakes in Italy, quit work for some time and fell down to pray.—Families ran out of their flats, fearing the walls would collapse.—Some people thought an explosion had occurred somewhere.—The falling of a tall chimney on a home for young women, scared the occupants out.—Telephone girls left switchboards. —A domestic was thrown off her feet.—A frightened wife called her husband.—Some people thought an explosion had occurred.—One man reported: "My wife and my sister were frightened and ran to me."—Hundreds of later risers were awakened by the earthquake.—A young woman stenographer, thinking some one had stepped up behind her chair, rocking it, exclaimed: "You stop that."—A man in a bath tub, seeing his image in motion in a swinging mirror, thought he was "verhext."—Many thought the shock due to blasting.—Some residents fled from their homes.—Some people experienced a dizzy feeling due to the motion.—One report says: "There was great excitement along the shore of Lake Michigan."—People feared a tidal wave.

Clinton, Ia.—Dishes were disturbed and broken.—Windows rattled. —The earth trembled as when there is an explosion.—The floor shook, as when there is an explosion.—The floor shook in the upper story of a large building.—Dishes were rattled down from shelves.— A door was sprung so it would not close.—Many people realized that it was an earthquake, and were stricken with fear.—Some thought the wind rattled the windows, or an explosion.—Occupants of large buildings told of feeling an unusual sensation.—Occupants of one building thought the shock was due to some work in progress on the upper floor.—A message, without signature, was received by one of the dailies, announcing the earthquake in a town near the city.—Telephone girls were scared.

Davenport, Ia.—The tremor was most noticeable in large office buildings.—Two shocks were felt.

Des Moines, Ia.—The earthquake was noticed by few people.

Des Plaines, Ill.—Chairs were overturned.—Mirrors were demolished.

DeWitt, Ia.—Buildings shook.—Dishes rattled.

Dixon, Ill.—There was a slight trembling of the earth.—Gas fires were shaken out.

Dubuque, Ia.—Office buildings were shaken.—The shock was felt most in the downtown districts.—Machinery rattled in factories.— Boxes and crates fell in stores.—Two shocks were felt.—Dishes to the value of eight hundred dollars were broken in a crockery store.—The upper part of high buildings swayed.—One-third of the inhabitants knew nothing of the earthquake.—Furniture moved in strange directions.—Furniture trembled.—Some claim they heard a rumbling sound before the shock.—Lamps were shaken from their rests.—Tables heaved.—Houses rocked perceptibly.—Dishes rattled on tables.—Chairs moved on their rockers.—Chandeliers heaved.—Floors heaved.—Win-

dows rattled.—Elevators swayed slightly.—Dishes and silverware moved on tables in hotels.—In the upper story of a hotel a sewing machine was tipped over.—In the upper story of a hotel a servant woman was pitched forward and nearly fell.—A house quivered.—People rushed from windows in terror, and alarm was widespread.—Several hundred people made their exit from a seven-story building, choking the stairways in their haste to escape.—Some people thought th shock was a blast in the stone quarries.—In factories where girls and women worked in upper stories, small panics were narrowly averted.—The women employed in the upper stories in an office building rushed in a panic to the stairs.—Men ran up from below, meeting them and quieting them.—A seamstress was surprised and alarmed when her sewing machine moved.

Eagle Point, Ia.—A high bridge swayed.—Buildings rocked.—Dishes rattled.—Bottles rattled in a drug store.—Bottles moved along a shelf in a drug store.—The shock caused alarm.

East Dubuque, Ill.—Dishes rocked from shelves and dashed on the floor.—Printing type in form, in a newspaper office, was pied.

Elgin, Ill.—Delicate instruments in the Elgin Watch Works were thrown out of gear.

Elizabeth, Ill.—Dishes were shaken and the contents spilled.—Buildings were noticeably jarred.—Windows rattled.—Two men in a store thought sacks of flour, stacked upstairs, had fallen down.

Elkader, Ia.—Windows in stores were shaken.—Articles were shaken from stands and dressers in a bed room.—Excitement was intense.—The earthquake was felt by several persons in town.

Evanston, Ill.—A chair in which the chief of police was seated, shook twice. The top floors in one of the University buildings shook.—Water in a tumbler was tippled.—Windows rattled.—A book case swayed one and one-half inch.—A vacant chair was rocked, hitting a man.—A team of horses were started on a runaway.—Instruction was interrupted in one of the classes in Northwestern University.—Occupants of some residences fled to the streets.—Patients and nurses in a hospital were alarmed.

Fort Madison, Ia.—Dishes and windows rattled.

Freeport, Ill.—Cracks were formed in cement walks.

Geneva, Ill.—A clock was stopped in the court house.

Gordon's Ferry, Ia.—The operators in a railroad depot rushed out.

Hannibal, Mo.—Two shocks were felt, lasting eight and thirty seconds, respectively.

Indianapolis, Ind.—The federal offices quivered.—A heavy iron bed was shaken.—A writing table shook.—The tower of the courthouse shook.—A woman, reclining on a couch, rolled down on the floor.—A man in a chair, resting his legs on a railing in the tower of the court house, felt his legs shake.

Jackson Junction, Ia.—There were heavy tremors.

Joliet, Ill.—Chairs were overturned.—Gas mains were made to leak

Kalamazoo, Mich.—The earthquake was noted.

Kenilworth, Ill.—Dishes fell from plate rails and broke.

Kenosha, Wis.—Plaster fell.—Wall paper cracked.—Chimneys top-

pled over.—One man thought the powder mill had exploded.—Some inhabitants "thought the island would sink."

Kewanee, Ill.—Some windows were broken.

Knox, Ind.—The shock frightened many people.—People rushed from buildings.—Some people thought the shock was an explosion in a distant powder mill.

Lake Forest, Ill.—Young people left the dormitories in Lake Forest University.—One professor dismissed his class.—Professors at the University recognized the earthquake.

Lake Geneva, Wis.—Two shocks were noted.—Water and milk were spilt.

Leonore, Ill.—A number of persons reported having felt the earthquake.

Lone Tree, Ia.—A rheumatic woman felt the vibration keenly, and told others of the disturbance, before it was generally known.

Lowden, Ia.—Buildings rocked.—Dishes were thrown off from a table.—Clocks stopped.

Window sashes were shaken.

Lyons, Ia.—Window sashes were shaken.—Dishes rattled.—Dishes were thrown from shelves.—A tea kettle was shaken from a stove.—There was a severe shaking up of dishes.—Dishes were broken.—Many thought the disturbance was due to the passing of heavy wagons.—On learning that the disturbance was general, an editor says he became convinced that there had been an earthquake.

Madison, Wis.—Some of the solution was spilled from the batteries in a railroad station.—Professor W. H. Hobbs, a prominent geologist and seismologist, is reported as having noted three distinct shocks.

Maquoketa, Ia.—The earthquake was very plainly felt.

Mason City, Ia.—There was a slight shock.

Maywood, Ill.—Plaster was loosened from a wall.

Milan, Ill.—Windows rattled in some buildings.—Dishes trembled in cupboards.—Pictures trembled on walls.—A woman thought she had an attack of heart trouble and sank frightened on a bed.

Monmouth, Ill.—Buildings were badly shaken.

Montague, Mich.—A man felt a swaying motion, while seated in a chair.—The earthquake was felt by several citizens.

Morning Sun, Ia.—Bottles and tinware rattled in a store.—The editor of the News Herald notes that the quake was not sufficiently severe to disturb his print shop.

Morrison, Ill.—A lamp was overturned.—Dishes were knocked off from a table.—Houses were shaken.

Mount Carroll, Ill.—Goods were thrown from shelves in the stores.—Chimneys toppled over.—Stove pipes were shaken out of chimneys.—Water was spilled from pans.—Racks were moved in the court house.—Bars in the jail rattled.—Windows in the jail rattled.—Everybody rushed into the streets.—There was much excitement.

Muncie, Ind.—The shock was variously attributed to blasting operations, to the rolling of heavy wagons, and to the passing of street cars.

Muscatine, Ia.—A quiver was felt by a few people.—Several people

afterward remembered feling a vibration, and attributing it to the moving of heavy objects in the building.

Muskegon, Mich.—Bric-a-brac fell to the floor.—Pictures swung.

North Chicago, Ill.—Bricks were hurled from a high scaffolding. —Workmen on a high scaffolding nearly fell.

Oak Park, Ill.—A leg was shaken loose from a piano in a school and this caused the piano to foll.—The cornice of an old mansion fell. —A hospital building rocked.—A baby was thrown out of bed.— Pedestrians were scared by falling brick.—A woman was thrown out of a chair.

Ottumwa, Iowa.—Some citizens claimed to have felt the quake.

Paw Paw, Ill.—There was no damage, but many people were frightened.

Peoria, Ill.—Plaster fell in a school building.—Many large buildings were shaken.—The shock was felt more on the bluffs than in the down town districts.—A rumbling sound was noted by a janitor in a school building.—Falling plaster caused a panic among the children in one school.

Peosta, Iowa.—Houses rocked.

Platteville, Wis.—An old building rocked.—A school building was cracked.

Pontiac, Ill.—Windows were shaken.—Articles were shaken from walls.

Princeton, Iowa.—A farm hand, who was standing in a barn, saw some hanging ropes gently vibrate. He also saw an iron support for a receptacle for water on a grindstone vibrate and heard a slight creaking in the building.

Rariton, Ill.—The earthquake caused buildings to creak and tremble.

River Forest, Ill.—A woman, who had been walking on crutches, ran out without them.

Rockford, Ill.—A street car was started down a hill.

Rock Island, Ill.—A man sitting in a chair noticed a dull shock which he referred to as something heavy that might have fallen in the attic.—The jar was distinctly felt in the third story of the main building of Augustana College, where book cases in the library were gently disturbed.—The first part of the disturbance was weakest. —The disturbance was felt by several persons at rest.

Sabula, Iowa.—Chimneys cracked.—Pictures rattled on walls—Furniture threatened to tumble over.—Heavy machinery in a printing office shook in good shape.—A ferry captain saw a large wave come to the Illinois shore in the Mississippi river.—The shock brought people out of their homes, some with alarm, others with curiosity.

Savanna, Ill.—Operators in a railroad depot rushed out.

Sears, Ill.—A desk rattled.—Goods rattled on the shelves in a store. —A heavy dresser quivered and shook.—Beds shook and quivered. —A lady thought she was affected by heart trouble and sank frightened on a bed.

Sinsinnawa, Ill.—Dishes and windows rattled.—Articles fell from walls..

South Haven, Mich.—Windows rattled violently.—Much china was broken.

Springfield, Ill.—A faint rumble was heard.—Windows rattled.—The earthquake was noted by nearly all people.—Many refused for hours to return to houses from which they had fled.—People rushed from houses.

Sterling, Ill.—Chandeliers were knocked down.—Pictures fell from walls.

Strawberry Point, Iowa.—Buildings were badly shaken.

Sycamore, Ill.—A clock was stopped in the court house.

Waukegan, Ill.—Clocks were stopped.—Pictures were thrown from walls.—Chimneys fell.—Linotype machines swayed violently.— A kitten was thrown across the room.—Two small children jumped out of bed crying, thinking the bed was falling to pieces.—Women fell on their knees and prayed.—People wobbled.—A prisoner in jail thought walls would fall and liberate him.—A woman came near being pitched through a glass door.—One man woke up from the shaking of the bed.—People in upper stories of houses ran down and out on the street.—A janitor in a school house thought a man had fallen from the flag pole, which was being repaired.—Sidewalks were seen to tremble and gently heave.—Tables shook.—Dishes rattled.—A house trembled.—A house gave a distinct raise, then trembled.—Pictures swung out from a wall.—A fern (in a pot) tipped over in one house.—Buildings were shaken.—A bed trembled.—A school house shook for one minute.—Books fell from cases in the court house.—The glass in a book case was shattered.—Chandeliers swayed in stores.—Plaster fell from a ceiling.—Book cases teetered.—Windows rattled.—A heavy safe rolled on timbers on which it rested.—A school (teacher and pupils) was curious, but not alarmed.—Some hands in the Corn Products Company's factory thought some heavy machinery had collapsed.—The city hall employees ran out on the streets.—One man described the sound accompanying the shock as a rush of wind, and said he heard it.—Grain was let out through cracks which were opened in the bins of a feed store.—One man heard a sound "like the rattling of a locked door."

West Union, Ia.—Buildings shook.

Wilmette, Ill.—Bottles rattled on the shelves in a drug store.

Winnetka, Ill.—Falling dishes were broken.

Zion, Ill.—Some Zionists, recalling a prophecy of the coming of the end of the world on the 29th of the month, are reported to have fallen on their knees to pray.

A. R. Crook.—"I am glad to see that in these interesting papers by Mr. Savage and Mr. Udden, we are at last getting down to 'rock bottom,' even though in this last paper on earthquakes the bottom appears to be somewhat shaky! While newspaper accounts of such occurrences are extremely interesting, I am not inclined to place confidence in their reports, and think that care should be exercised in accepting any contributions which they may make in any department of science.

For example, within the last few years, upon reading at fifteen different times of the falling of a meteorite in some region where Mr. Blank had found the specimen, I have written to Mr. Blank. In twelve out of fifteen cases my letter was returned from the post office marked 'no such person known at this office,' From the other three letters nothing was heard."

F. C. Baker.—"The Chicago papers described a case of heads of mammoths which was put on exhibition at the Chicago Academy of Science, as an interesting collection of humming birds."

R. M. Bagg.—"There is interest in determining the causes of the earthquakes which occur in the great Mississippi region, a region looked upon as practically free from siesmic action.

These earthquakes may be possibly accounted for by supposing that they are due to crustal disturbance through faulting due to depression of the Gulf of Mexico through *loading* of *sediment* carried by rivers emptying into the Gulf, especially the Mississippi river, which deposits each year one subic mile of sediment 268 feet high in the gulf. This causes continual sinking though not the initial subsidence. The erosion of the Mississippi valley and deposit southward in the gulf may cause readjustment of equilibrium through faulting as Mr. Savage and members of Geological Survey know and have shown on their maps of the State. These earthquake movements may be reasonably expected to recur from time to time, due to readjustment and an attempt of the crust of earth to regain isostatic conditions."

J. A. Udden:—With regard to the reliability of newspaper data, they must be taken for what they are worth and should be used with common sense discretion. Much of the material collected for this study was not used. The character of the isoseismals, based on separate determinations of intensities of the earthquake for a hundred localities, speaks well, it appears to me, for the reliability of the data used. The use of such data in the study of earthquakes is nothing new. In the nature of the case, the isoseismals below seven in a scale of ten are largely located on hearsay evidence for all earthquakes which are studied. Such data are necessarily obtained from untrained

observers. They are the best that can be obtained. The author's chief object in presenting this paper has been to awaken interest in these phenomena, in order that more and better observations may be secured in the future.

H. S. Pepoon then presented the following paper:

THE FOREST ASSOCIATIONS OF NORTHWESTERN ILLINOIS.

A large area in northwestern Illinois, which, roughly speaking, occupies practically all of Jo Daviess county, except a narrow strip along the northeastern border, and a small portion of the adjacent counties of Carroll on the south and Stephenson on the east, is or rather was occupied by almost continuous forest growth. In Illinois. as a rule, the wooded lands lie adjacent to streams, but here there is no such distribution. Ridge and valley alike have this forest covering. The accompanying map will show the distribution of woods, which sustain a remarkably close relation to that peculiar physiographic feature called the "driftless area."

A very large percent of the original woodland has disappeared before the ax and "grub-hoe," and it is no exaggeration to state that in many parts not more than ten percent of the first growth remains standing, so that the aspect of large areas is that of a rolling prairie; but even now the remaining portion is amply sufficient to form a basis for the study of the forest associations, and all the more so because each passing year further decreases the number of remnants.

This paper, therefore, will partake of the historical as well as the actual in dealing with the subject, and it is largely with the idea in mind of preserving many interesting facts of distribution that it is undertaken.

The Forest Associations are so intimately and vitally connected with the character of the soil, the amount of water supply, and the greater or less perfectness of drainage, that it

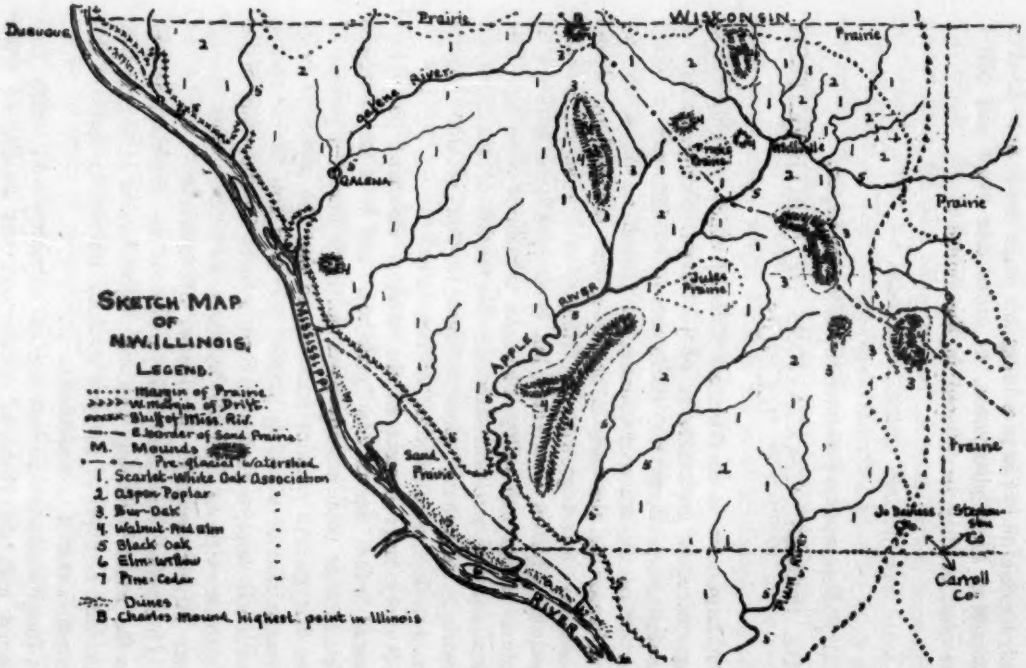

Dubuque
Prairie
WISCONSIN
Prairie
Galena River
Galena
Prairie
Apple River
Sand Prairie
Prairie
Mississippi
Prairie
Carroll Co.
Sketch Map of N.W. Illinois.
Legend.
Margin of Prairie
Wis. Margin of Drift.
Bluff of Miss. Rid.
Border of Sand Prairie
M. Mounds
Pre-glacial Watershed.
1. Scarlet-White Oak Association
2. Aspen-Poplar
3. Bur-Oak
4. Walnut-Red Elm
5 Black Oak
6 Elm-Willow
7 Pine-Cedar
Dunes
B. Charles Mound, highest point in Illinois

Fig. 10.

is necessary to obtain a reasonable conception of these elementary factors in distribution. No region of Illinois probably compares to Jo Daviess county in the extent and perfection of the drainage elements, for it must be remembered that we are dealing with an ancient land surface that for milleniums has been subjected to the erosive action of frost and rain, so far as we know, without a break since the days of the Niagara limestone. Countless ravines and small and large valleys cut up the surface in every directon, so that a plot of level land is a rarity, every where slopes, more or less pronounced, being the topographical feature paramount in the landscape. Only on the expanded summits of the watersheds are there any areas of poor drainage found and these are of limited extent, and yet, as shown hereafter, they are sufficiently potent to produce a forest association. The water table is in many parts very deep in the earth, this being practically true of large portions of the Galena limestone, and yet only on very limited and very local land surfaces is a genuine scarcity of water to be found. As the rainfall is about forty inches per annum, plant life rarely suffers any serious drawback from this source. The soil is everywhere the result of disintegrated rock remaining in situ except on the "bottoms" of the streams, small and large, where considerable areas of alluvium are found, and again some more or less pronounced loess soils, particularly in evidence in some of the area bordering the Mississippi river (see Soil Survey of the Dubuque Area). A clay subsoil, grayish, yellow, or even ocher red, with a few flints here and there, of many feet thickness, merges into a surface soil of clay, clay-loam, or even a black humus in limited districts, the latter particularly in evidence as border deposits where the forest and prairie join, or at the junction of Niagara and Cincinnati shales. A very limited amount of sand is found in these soils, but near the Mississippi river are several square miles of sandy soils of varying purity, evidently of river and wind formation.

Owing to the general uniformity and topography, we find

one general forest association and a number of minor ones that may be designated as follows:

a. The scarlet and white oak, a general forest growth.
b. The aspen-poplar.
c. The red elm-walnut.
d. The white elm-willow.
e. The black oak.
f. The bur oak.
g. Pine red cedar.

The scarlet and white oak association is the all pervading one and everywhere gives the general tone to the woodlands. The association consists almost entirely of the oaks named, but varies in every possible degree between a pure white oak and a pure scarlet oak growth. In general, however, there will be a small preponderance of one or the other species according as the soil has more or less humus and less or more clay. The richer the soil, the more the scarlet oak abounds, and the poorer and more clayey, the more abundant will be the white oaks; most of the trees of this association are second growth; a typical example, extending over one-half mile square, having a tree for every five or ten feet square of land surface, or 400 to 1600 to the acre. These trees will average 12 to 16 inches in diameter, 50 to 70 feet in height, and represent a time growth for the scarlet oaks of 50 years, and for the white oaks 75. Here and there large white oaks are to be seen, two to four feet in diameter and up to 300 years of age. Many such are suitable for sawmill material, but their number is very rapidly diminishing. Occasional scarlet oaks 2 feet to 30 inches in diameter are found, of a probable age of a century or more. Often there are absolutely no other tree species included, and this will certainly be the case where the soil is of moderate fertility. As the soil thins, the white oaks with an occasional shag bark hickory presents a solid front. Running to the other extreme of soil richness, there will be found a few specimens of black cherry, pig-nut hickory, red oak and very rarely a red elm and bass wood.

As this exclusive association constitutes most of the forest

growth of Jo Daviess county, it follows that the two oak species are the source of practically all the wood and timber supply of the region. The height noted above nowhere approaches the till growth so commonly seen in Michigan, Indiana, and Ohio. For post timber the young white oaks are very valuable; but the scarlet oaks are almost worthless for such a purpose, having but little durability in contact with the soil.

The undergrowth in the association is as a rule more marked by its absence than presence, great portions of the woods being absolutely devoid of it. The most common shrub is the hazel (*Corylus americana*), that in some of the moister places attains a height of 16 feet and a diameter of 2½ inches. Blackberries (*Rubus nigrobaccus*) are abundant in isolated patches that bear a constant relation to abundant water, being a certain feature of ravine heads. An occasional grapevine (*Vitis vulpina*) is seen and in rich soil the Virginia creeper (*Psedera*). Of substratum trees, certain hawthorns (*Crataegus tomentosus* and *C. mollis*), the wild plum (*Prunus americana*), black haw (*Viburnum prunifolium*), and choke-cherry (*Prunus virginiana*) complete the list. The plums are remarkable for fruit variation of every size, from bullets to great oval fruits 1½ inches in diameter, green, red, yellow and variegated, acerb, sour, and sweet in flavor.

The herbaceous plants in the white oak type are very few in number, either in individuals or species, and the botanist has hard work to obtain anything of note. Only a very few plants are in any sense characteristic. *Carex pennsylvanica is* everywhere, so also are innumberable spots of *Antennaria;* in the open places *Potentilla canadensis* is common; this is certainly a scant list. As the scarlet oaks predominate, and particularly where the humus is in large amount, there is found a great increase in these forms of plant life, and individuals and species become exuberant in numbers and growth. As an example, it may not be amiss to record again what I stated in Plant World, volume VII, that on the old home farm in Warren township of this county, 230 acres in extent, and having

130 acres of the scarlet oak woodland, there were found 355 species of plants.

In the scope of this paper it will be necessary to mention but a limited number of the more characteristic forms. Nowhere is the fact more plainly emphasized than here, that the *exposure* is a dominating factor in determining distribution of plant life. In this association type it is only on northeasterly slopes that the yellow lady slipper (*Cypripedium hirsutum*) is found, and then only in dense shade. This species is very local, not more than one or two "patches" being found in a township, and it is always in close proximity to the two ferns *Osmunda Claytoniana*, and *Asplenium Filix-foemina*, both in great abundance. These patches are invariably in the moist rich shade of ravines having an eastward trend. The twayblade (*Liparis liliafolia*) is a rare associate, and *Habenaria bracteata* and *Orchis spectabilis* are yet rarer. It is worth recording here that the last species was found by me in 1891 in identically the same situation and exposure, three miles southwest of Lewiston, Fulton County, growing so abundantly as to tint the woodland with its beautiful colors. Other species not so "finicky" as to exposure are *Trillium, declinatum, Uvularia grandiflora, Allium tricoccum, Podophyllum, Geranium maculatum, Desmodium grandiflorum, Viola sororia, Sanicula canadensis, Osmorhiza, Aralia racemosa, Steiromma ciliatum, Triostium aurantiacum.*

On the flattened crests of nearly all the watershed ridges, or rather, in many cases, the broad elevations between adjacent streams are poorly drained areas, thin-soiled as a rule, and occasinally with a small circular pond, the remains of an ancient "buffalo wallow." These tracts are the ideal home of the *aspen-poplar association.* They are generally of small extent, but now and them assume the proportions of a respectable woodland. The individual trees are commonly scattered, though not infrequently forming dense growths. Here and there are small open spaces surrounded by luxuriant clumps of hazel, which send out arms and straggling bands among the aspens. Practically the only other woody plant of size is the pussy willow

Salix discolor). The roots of the poplar barely penetrate the soil, which is water-saturated in spring and early summer, and often they lie on the surface for a rod or more. The aspens attain at times a height of 60 feet and a diameter of 28 inches, but more commonly they are dense growths, 30 to 40 feet tall, and 4 to 6 inches in diameter. The ultimate fate of these latter trees is the grove of scattered adults, all that remains of the former hosts in the struggle for existence.

In these aspen associations there is practically nothing herbaceous that is characteristic, except that it is here that the rare orchid *Habenaria bracteata* is most surely to be found. In the small prairies that have been referred to as certain to be found with every such association, and doubtless of Indian fire origin (see later) a few species are ever present. *Baptisia leucantha, Polygala viridescens* carpeting large areas, *Koellia virginiana, Gerardia tenuifolia,* the rare *G. auriculata,* and a few plants of *Rumex Britannica,* make up the list. As hinted, these aspen flats were prairies of considerable extent in the days of Indian control, and were continued as such by the habit of firing the grass in spring that new and fresh growth might be afforded to the game of the region. When the first white men came to the country about 1800, a horseman could ride through the open woodland or through the openings in every direction. With the coming of the whites there was a cessation of the fires, and the lodgment and growth of the wind-snow aspen seed on the moist open lands caused their gradual reduction to the small open spots which are now so characteristic.

Most of the soils on which these aspens grow are what locally are termed "hard pan," having a dense impervious clay subsoil that renders the areas very marshy in spring. Usually in clearing the woodland these places are the first to be grubbed out, on account of the ease with which the laborer can remove the tree, root and trunk. The surface roots aid greatly in this undertaking. Properly fertilized and particularly so if holes are dug through the hard pan for drainage, the land produces good crops. This hard pan explains the formation of the wallows before mentioned, which were very common on all such flat

lands as late as 1890, but which have now almost entirely disappeared. These circular ponds were rarely more than 18 inches deep and generally contained water during the entire year.

The remaining associations are very local, or are very much circumscribed by the encroachments of agricultural operations, but even now in the aggregate covering many square miles of Jo Daviess county. So scattered are they that they show but little influence on the general tone of the forest features, and without reference to the order given above each may be briefly considered.

While it is true that occasional bur oaks may be found widely scattered, as isolated specimens here and there, and in all probobility squirrel or pigeon sown, it is equally true that genuine associations of this species occur as fringes or limited patches, always denoting good strong soil, well drained, and in many places designated by the term "bur oak openings." The origin of such a term is obscure and I make no attempt to solve it. In general, while the bur oak is the dominant species, this association is not a pure growth, but a number of different trees is almost certain to be found. The oaks are often very large, with wide-spreading branches, and have a trunk diameter of 2 to 4 feet, and height of 80 feet, and in a typical woodland will stand 50 or 60 feet apart.

Just what the cause may be for these limited areas devoted to a particular species is not positively determined, but the conjecture is made that where the underlying lime rocks have become disintegrated sufficiently and are near enough the surface for good drainage, and where finally much humus has accumulated, such places seem to be the ideals for bur oak development. In nearly all of the best examples that are known to the writer, this association occupies the highest horizon of the Galena limestone at the point where it is overlaid with crumbling shales of the Cincinnati formation. Such a region has an abundant moisture from the innumerable springs that have their origin in the sloping steeps of the latter strata, rising in disintegrated masses to meet the weather worn escarpments of the Niagara.

An external factor, strangely enough, almost entirely precludes the determination of a peculiar herbaceous flora for this association, viz: that owing to the enormous production of very nutritious acorn food, such groves are almost invariably "hog pastures," and all wild growth has either become exterminated, or so mixed with pasture weeds as to become useless for purposes of study.

Above this growth on all the lands lying adjacent to the great Niagara mounds, so common and conspicuous a feature of the landscape of northwestern Illinois, is to be found an irregular belt or zone, occupied largely by black walnut and red elm, which here and there, by reason of the erosion caused by some drainage line, assumes the form of a great amphitheater, surrounded on all sides, but the outflowing, by the steep slopes of the mound, partly Cincinnati and partly Niagara, both talus-like in appearance. In such places the species named reach magnificent proportions, are very numerous in individuals, and are commonly associated with basswood and red oak in much less numbers. The soil is very rich, full of humus, plentifully supplied with moisture, and is by all odds the most prolific in species of any area in the entire region. Here are to be found in great profusion those species that are the rarest of plants elsewhere.

Nowhere except in the immediate valley of the Mississippi river are the trees so luxuriant. The undergrowth resembles in most particulars the rich scarlet oak type of the first association and many of the herbaceous plants are the same. From this it would seem that shallow-rooted plants find the areas quite similar, but the deep-rooted trees evidently discover something in the one region not found in the other, and this something is potent enough to produce a great difference in tree growth.

In these favored ampitheaters are to be found, among others, the following herbaceous plants various rare Carices as *C. albursina, pedunculata, plantaginea, Frankii, Erythronium albidum* by thousands, *Uvularia grandiflora, Orchis spectabilis, Asarum canadense Actaea rubra, Sanguinaria, Dicentra cucul-*

laria, Caulophyllum, Podophyllum, Dentaria laciniata, Viola scabriuscula, Geranium, maculatum, Impatiens aurea, Oxalis racemosa, Phlox divaricata, Hydrophyllum virginianum, Scutellaria versicolor, Agastache, Campanula americana.

The *black oak association* is remarkable for at least two things, viz: that commonly the oak is the only notable tree species, and further that wherever dry, barren, or eminently unfavorable land surfaces are found, there it will be certain to grow. These barren soils are to be found in three well-marked and seemingly quite different topographic areas: first, on the elevated summit ridges of the Niagara mounds; second, on the equally dry and rocky brows of the Apple river and Mississippi river bluffs; third, in the dune region adjacent to the Mississippi on sand prairie in the southwestern part of Jo Daviess county. A height of 60 feet and a diameter of 2 feet will mark the largest growths. They are generally scrawny, often hollow, and only in young trees thriftly in appearance. The most thrifty specimens are found on the tops of the mounds and in spots of some comparative richness of soil. May it not be true that the oak grows in pure sand of the dune or on the dry rocky knoll because it there finds little or no competition, and not because it would not do better on a richer soil if it were to be given possession. Seemingly an isolated species it consorts poorly with other plant growths of tree proportions.

With the black oak are to be found a very few tree species, most prominent among them an occasional great-toothed poplar (*Populus grandidentata*), June berry (*Amelanchier canadensis,*) and several species of *Crataegus.* The shrubby growth is mostly hazel, Jersey tea, and white dogwood (*Coruns paniculata*). Among herbaceous species a few only are conspicuous: various species of *Desmodium* and *Lespedeza, Viola pedata, Dodecatheon, Lithospermum canesens, Isanthus, Hedeoma, hispda, Gerardia laevigata, Liatris scariosa, Kuhnia, Aster linarifolius, A. ptarmicoides.* The sand dune flora of this oak association has some interesting additions to the above, notably *Opuntia, Rhus canadensis, Synthyris, Krigia virginiana, Tephrosia virginiana* and

Anychia. The oaks of this sandy district are never tall, generally very scraggy, and at best do not show any luxuriance of growth. This black oak forest, if it can be so called, varies from a few rods to three-eights of a mile in width, and extends along the Mississippi river for a number of miles, covering the river dune, and speading out over the gently rolling sandy prairie, but everywhere cut off from the forest growth of the uplands by a mile or more of sandy plain. On the bluffs, as before mentioned, the species is again found. The history of how it found a lodgment in the sand prairie nearest the river is an interesting bit of plant distribution. Probably carried by squirrels from woods adjoining the northern and southern ends of the prairie to the occasional trees of other species, as ash, honey locust and cottonwood, the acorns were covered by the drifting sand and so found soil and moisture enough to germinate and attain the tree estate. Plain grasses and other plants preclude much sand movement further from the immediate source of the sand, the river sand bars, and there is no possibility of the acorns becoming covered. It is interesting to note that the oak margin is not an even front, but is sinuous with advancing or retreating angles, indicative of the combat between forest and plain for the possession of the sands.

The *pine-cedar association* is one of vertical rather than horizontal aspect, occupying as it does all the cliffs of the Apple river and its tributaries, as they cut through the Galena limestone to reach the main stream or the Mississippi river into which it debouches. Certain sections of the Galena river also possess these cliffs and have the same trees. Undoubtedly we have here the evidences of either the *last stand* of a dying race, or the choice of such an inhospitable habitat to avoid competition, both pine and cedar having many xerophytic characteristics that fit them for life on the solid rock, into the crevices of which their roots are insinuated. The white pines attain a height of 110 feet, a diameter of 4 feet. The red cedar rarely assumes a growth of more than 30 feet. The herbaceoous plants of these cliffs have been fully discussed in the Cliff Flora of Jo Daviess county (Vol. II. Transactions Ill. State Academy of

Science). Perhaps no better illustration is needed to show that anchorage is a chief end of a tree root system, and not primarily to obtain a major amount of the plant food needed in up-building trunk and branches. Here again the writer must remark on the marvelous difference in the habitat of these two trees from the swamp home of the one in Michigan and the other in Massachusetts.

The alluvium of all the streams of any size, and reaching the greatest development along the Mississippi river, is the chosen home of the last association to be discussed, the *elm-willow.* As a matter of course, the soil is exceedingly rich but often very wet, although rarely marshy, and subject to every considerable overflow of the adjacent river. White elms are everywhere the common tree on the drier portions, assuming magnificent proportions (100 feet high and with a diameter of 6 feet). On the moister lands the soft maple grows to immense size, one specimen having a diameter of 7 feet. Near the water the black and peach willows are common, and commonly are the river bank trees. White and black ash are common, the latter in genuine swamps. Here and there are clumps of giant sycamores, that are the largest trees of the entire region. Where alluvial soil disappears and sand begins, the sand-bar willow, (*Salix longifolia*), is the dominant form, growing in dense thickets, and serving as a catch-all for all the debris of the great river, which debris is the beginning of the true bottoms.

Associated with these trees are a number of herbaceous plants that are characteristic. Among them we note *Leersia virginica* and *oryzoides, Cinna, Elymus, Polygonum* of many *species, Impatiens pallida* and *biflora, Convolvulus sepium, Cuscuta* of several species, *Stachys palustris* and *aspera, Scutellaria lateriflora, Chelone, Mimulus ringens, Lobelia cardinalis, Helianthus,* and *Solidago.*

In concluding these words about the forest trees, it will be advisable to mention a few species that may be called sporadic, to use a medical term, that is a few of one species found in a circumscribed locality, and perhaps no others known in the whole district or separated by miles of intervening territory.

The coffee bean is a marked example. A clump of six trees, 50 feet in height, occurs on the gravelly border of Apple river bottom, two miles below Millville, and no others are known until the bluffs of the Mississippi are reached, 25 miles northwest. *Morus rubra*, the mulberry, has exactly the same distribution. *Carya illinoiensis*, the pecan, occurs at one place on the elevated bottom of the Mississippi river, a single specimen 90 feet in height, and 3.5 feet in diameter, in the midst of a woodland of elm and maple. *Betula alba* is occasional along the bluffs of the Apple river, and again on the summits of Benton mound, at 300 feet greater altitude (1200 feet above the level of the sea,) and 10 miles distant. Honey locust exists as few specimens on sand prairie; *Ulmus racemosa* is seen only on the west branch of Apple river. It would be a difficult task to explain the origin of these species, some seemingly from the south, and one or two from the far northeast.

Enough has been said to give a glimpse of the tree distribution of the region, and the grouping that seems to be rational and most easily accounted for. Errors of judgment there may be, but the points of distribution are facts that I have sought the best explanation for, from the data at my command.

LIST OF TREES OF NORTHWESTERN ILLINOIS.

1 Pinus strobus,
2 Juniperus virginiana,
3 Salix nigra,
4 Salix amygdaloides,
5 Salix lucida,
6 Salix longifolia,
7 Salix discolor,
8 Salix rostrata,
9 Populus tremuloides,
10 Populus grandidentata,
11 Populus deltoides,
12 Juglans cinerea,
13 Juglans nigra,
14 Carya illinoensis,
15 Carya ovata,
16 Carya glabra,
17 Carya cordiformis,
18 Ostrya virginana,
19 Carpinus caroliniana,
20 Betula alba,
21 Quercus alba,
22 Quercus macrocarpa,
23 Quercus bicolor,
24 Quercus muhlenbergii,
25 Quercus rubra,
26 Quercus palustris,
27 Quercus coccinea,
28 Quercus velutina,
29 Ulmus fulva,
30 Ulmus americana,
31 Ulmus racemosa,
32 Celtis occidentalis,
33 Morus rulra,
34 Hamamelis virginiana,
35 Platanus occidentalis,
36 Pyrus coronaria,
37 Pyrus ioensis,
38 Amelanchier canadensis,
39 Crataegus punctata,
40 Crataegus tomentosa,
41 Crataegus mollis,
42 Crataegus macracantha.

43 Crataegus macrosperma,
44 Prunus serotina,
45 Prunus virginiana,
46 Prunus pennsylvanica,
47 Prunus nigra,
48 Prunus americana,
49 Gymnocladus canadensis,
50 Gleditsia triacanthos,
51 Zanthoxylum americanum,
52 Ptelea trifoliata,
53 Rhus typhina,
54 Euonymus atropurpureus,
55 Acer saccharum,
56 Acer saccharum nigrum,
57 Acer saccharinum,
58 Acer negundo,
59 Tilia americana,
60 Cornus alternifolia,
61 Fraxinus americana,
62 Fraxinus pennsylvanica,
63 Fraxinus pennsylvanica lanceolata,
64 Fraxinus nigra,
65 Viburnum opulus,
66 Viburnum lentago,
67 Viburnum prunifolium.

F. L. Charles moved that the President be authorized to appoint a committee of three to cooperate with existing agencies for the advancement of nature study in elementary schools, and to report at the next meeting; and that the Council be authorized to place at the disposal of this committee such funds for correspondence as may seem expedient.—Carried. (See Page 3.)

Upon motion of J. A. Udden it was voted that the Academy express its gratitude for the pleasant way in which it had been entertained by the University, by organizations and by individuals.

Isabel Smith extended an invitation to the Academy to hold one of its meetings at some future time at Jacksonville, stating that the Illinois College, one of the oldest institutions in the state, would do what it could to give the Academy a cordial welcome and successful meeting.

President Forbes stated that the committee on Ecology was ready to enlarge its membership. Since the committee was to be continued, this action would be in line with Prof. Galloway's suggestion.

C. W. Andrews gave notice concerning the work of scientific bibliography which was being carried on at the Crerar Library.

T. J. Burrill.—"It is proper to say that the twin cities of Urbana and Champaign invite you to return next year and the next and the next."

Upon motion of C. C. Adams it was voted to adjourn.

The following is the complete list of members elected Feb. 18 and 19, 1910.:

Babcock, Oliver B., M.D., 1100 South 2nd, Springfield. (Physician.)

Baer, Carlyle, Chicago Academy of Sciences, Chicago. (Nat. History.)
Bagley, W. C., Ph.D., Uni. of Ill., Urbana. (Educational Psychology.)
Baker, Charles Lawrence, B.S., Uni. of Chicago, Chicago. (Geology.)
Baker, I. O., C.E., University of Illinois, Urbana. (Civil Engineering.)
Benson, Peter, A.B., Augustana College, Rock Island. (Mathematics.)
Berg, E. J., Sc.D., Uni. of Ill., Urbana. (Electrical Engineering.)
Blair, J. C., M.S.A., 810 Oregon St., Urbana. (Horticulture.)
Bryant, Earl R., A.B., Millikin University, Decatur. (Biology.)
Burgess, L. L., Ph.D., 409 East Green St., Champaign. (Chemistry.)
Burke, C. E., University of Illinois, Urbana. (Chemistry.)
Burns, Wm. G., Section Director, U. S. Weather Bureau, Springfield.
Carpenter, F. W., Ph.D., 1008 W. Oregon St., Urbana. (Zoology.)
Cederberg, Wm. E., Ph.D., Augustana College, Rock Island. (Math.)
Child, C. M., Ph.D., University of Chicago, Chicago. (Zoology.)
Coad, Bert R., 1817 Spruce St., Murphysboro. (Entomology.)
Coe, Chester M., Danville. (Entomology.)
Collins, J. H., A.M., Supt. City Schools, Springfield. (Nature Study.)
Cooper, Wm. S., University of Chicago, Chicago.
Cort, W. W., A.B., 1206 W. Springfield Ave., Urbana. (Zoology.)
Crowe, A. B., Charleston. (Physics.)
Daniels, L. E., LaPorte, Ind. (Conchology.)
Davenport, Eugene, M. S., Uni. of Ill., Urbana. (Agriculture.)
Egan, J. E., A. B., 906 South Fifth St., Champaign. (Chemistry.)
Emmett, A. D., A.M., 707 W. Illinois St., Urbana. (Chemistry.)
Emmons, W. H., Ph. D., Uni. of Chicago, Chicago. (Economic Geology.)
Ernest, T. R., A. M., 605 E. Springfield Ave., Champaign. (Chemistry.)
Finley, C. W., 5620 Kimbark Ave., Chicago. (Zoology.)
Gault, B. T., Glen Ellyn. (Ornithology.)
Gill, F. W., B.S., 601 W. Illinois St., Urbana. (Chemistry.)
Girault, A. A., M.S., Urbana. (Entomology.)
Gooding, Chas. W., High School, Champaign. (Biology and Chemistry.)
Gordon, H. B., University of Illinois, Urbana. (Chemistry.)
Gordon, W. O., 905 S. Sixth St., Champaign. (Chemistry.)
Green, Bessie, A.B., 401 S. Wright St., Champaign. (Zoology.)
Hagler, Elmer E., M.D., Capitol & 4th Sts., Springfield. (Physician, Oculist.)
Hand, E. E., Wendell Phillips High School, Chicago. (Zoology.)
Harrison, B. H., 304 East Daniel St., Champaign. (Chemistry.)
Hawk, P. B., Ph.D., 801 West Nevada St., Urbana. (Chemistry.)
Hayford, John F., C.E., Northwestern Uni., Evanston. (Engineering.)
Henriksen, Martin E., B. S., 509 E. University A., Champaign. (Zoology.)
Hill, N. Wm., 303 West Oregon St., Urbana. (Chemistry.)
Hinkley, A. A., Dubois. (Conchology.)
Homberger, A. W., A.M., 508 E. Daniel St., Champaign. (Chemistry.)
Jacobson, A., B.S., 501 E. Clark St., Champaign. (Chemistry.)
Jesse, R. H., Jr., Ph.D., 1001 W. California Ave., Urbana. (Chemistry.)
Jessup, J. M., Uni. of Chicago, Chicago. (Geology and Paleontology.)
Johnson, H. W., Mt. Olive. (Psychology and Biology.)
Jones, G., Ph.D., 409 East Green St., Champaign. (Chemistry.)
Kindred, Granville L., Ill. Watch Co., Springfield. (Mechanical Eng.)
Kingsbury, H. B., A.B., 607 S. Sixth St., Champaign. (Mathematics.)
Kinnear, T. J., A.B., M.D., 400 Myers Bldg., Springfield. (Medicine.)
Knight, Luther, M.S., 401 Springfield Ave., Champaign. (Chemistry.)
Kressman, F. W., B.S., 210 E. Clark St., Champaign. (Chemistry.)
Langelier, W. F., B.S., 1005 West Illinois St., Urbana. (Chemistry.)

LaRue, Geo. R., A.M., 612 S. Coler Ave., Urbana. (Zoology.)
Laughlin, E. V., High School, Champaign. (Physiology and Physiography.)
Lehenbauer, P. A., A.M., University of Illinois, Urbana. (Botany.)
Linder, O. A., 22 Fifth Ave., Chicago. (Editor Svenska Amerikanaren.)
Lindgren, J. M., A.M., 306 S. Fourth St., Champaign. (Chemistry.)
Lumbrick, Arthur, (College of Agriculture,) Urbana. (Agriculture.)
Lyon, Thos. E., B.S., L.L.B., Hay Bldg., Springfield. (Lawyer.)
MacInnes, D. A., University of Illinois, Urbana. (Chemistry.)
MacNeal, W. J., Ph.D., Urbana. (Bacteriology.)
Marshall, Ruth, Ph.D., Rockford College, Rockford. (Biology.)
McAllister, H. T., 1002 W. California St., Urbana. (Chemistry.)
McConn, C. M., A.M., 1002½ W. California Ave., Urbana. (Education.)
McDunnough, Dr. J., Decatur. (Lepidoptera.)
Miller, G. A., Ph.D., University of Illinois, Urbana. (Mathematics.)
Mitchell, H. H., University of Illinois, Urbana. (Chemistry.)
Morrison, H. T., M.D., First and Miller, Springfield. (Gen. Medicine.)
Mortensen, Henry T., Frances W. Parker School, Chicago.
Mumford, H. W., Champaign. (Animal Husbandry.)
Munson, S. E., M.D., 612 S. Second St., Springfield. (Medicine.)
Nickell, L. F., A.B., 307 E. Green St., Champaign. (Chemistry.)
Palmer, Geo. Thos., M.D., 1733 S. Fourth St., Springfield. (Medicine.)
Partridge, N. L., Y. M. C. A., Champaign. (Agriculture.)
Patterson, Alice J., Normal. (Entomology: Nature Study.)
Prince, S. Fred, 612 S. Coler Ave., Urbana. (Zoology.)
Read, J. W., M.S., Illinois College, Jacksonville. (Chemistry.)
Richardson, R. E., A.M., State Lab. Nat. Hist., Urbana. (Ichthyology.)
Rolfe, C. W., M.S., Champaign. (Geology.)
Schultz, W. F., Ph.D., 926 W. Green St., Urbana. (Physics.)
Sevrens, O. F., 105 E. Green St., Champaign. (Zoology.)
Smith, A. L., 205 E. Stoughton St., Champaign. (Zoology.)
Smith, G. McP., Ph.D., 708 South Fourth St., Champaign.
Smith, Huron H., Field Museum, Chicago. (Dendrology.)
Smith, Orrin H., High School, Champaign. (Physics.)
Smith, Sidney B., B.S., 710 S. Sixth St., Springfield. (Farming.)
Stephenson, E. B., M.S., 617 S. Wright St., Champaign. (Physics.)
Stoek, H. H. E.M., 1005 W. Green St., Urbana. (Mining Engineering.)
Strachan, E. K., B.S., 410 E. Chalmers St., Champaign. (Chemistry.)
Talbot, Eugene S., M.D., LL.D., 198 Goethe St., Chicago. (Stomatology.)
Tatnall, Robert R., Ph.D., 624 Lincoln St., Evanston. (Physics.)
Thomson, Frank D., A.M., Prin. H. S., Springfield. (Economics-Hist.)
Udden, Anton D., Rock Island H. S., Rock Island. (Physics and Math.)
Umbach, L. M., Naperville. (Botany.)
Van Cleave, H. J., B.S., 809 W. Nevada St., Urbana. (Zoology.)
Van Brunt, G. A., A.M., 204 E. John St., Champaign. (Chemistry.)
Vestal, A. G., 510 Goodwin Ave., Urbana. (Ecology.)
Wagner, C. L., 405 E. Green St., Champaign. (Chemistry.)
Ward, H. B., Ph.D., Uni. of Ill., Urbana. (Zoology, Parasitology.)
Washburn, E. W., Ph.D., 210 W. Park St., Champaign. (Chemistry.)
Watt, L. A., 405 E. Green St., Champaign. (Chemistry.)
Welch, Paul, A.B., Decatur. (Zoology.)
Wilczynuski, E. J., Ph.D., Uni. of Ill., Urbana. (Mathematics.)
Williamson, Warren, A.B., University of Illinois, Urbana.
Zeleny, C., Ph.D., 606 S. Matthews A., Urbana. (Experimental Zoology.)

A. R. Crook, Secretary.

CONSTITUTION AND BY-LAWS

ILLINOIS STATE ACADEMY OF SCIENCE

CONSTITUTION

ARTICLE I. NAME.

This Society shall be known as THE ILLINOIS ACADEMY OF SCIENCE.

ARTICLE II.. OBJECTS..

The objects of the Academy shall be the promotion of scientific research, the diffusion of scientific knowledge and scientific spirit, and the unification of the scientific interests of the State.

ARTICLE III. MEMBERS.

The membership of the Academy shall consist of *Active Members, Non-resident Members, Corresponding Members, Life Members, and Hororary Members.*

Active Members shall be persons who are interested in scientific work and are residents of the State of Illinois. Each active member shall pay an initiation fee of one dollar and an annual assessment of one dollar.

Non-resident Members shall be persons who have been members of the Academy but have removed from the State. Their duties and privileges shall be the same as those of active members except that they may not hold office.

Corresponding Members shall be such persons actively engaged in scientific research as shall be chosen by the Academy, their duties and privileges to be the same as those of active members, except that they may not hold office and shall be free from all dues.

Life Members shall be active or non-resident members who have paid fees to the amount of twenty dollars. They shall be free from further annual dues.

Honorary members shall be persons who have rendered distinguished service to science and who are not residents of the State of Illinois. The number shall not exceed twenty at one time. They shall be free from all dues.

For election to any class of membership the candidate's name must be proposed by two members, be approved by a majority of the committee on membership, and receive the assent of three-fourths of the members voting.

All workers in science present at the organization meeting who sign the constitution, upon payment of their initiation fee and their annual dues for 1908 become charter members.

Article IV. Officers.

The officers of the Academy shall consist of a President, a Vice-President, a Chairman of each section that may be organized, a Secretary, and a Treasurer. These officers shall be chosen by ballot on recommendation of a nominating committee, at an annual meeting, and shall hold office for one year or until their successors qualify. They shall perform the duties usually pertaining to their respective offices.

It shall be one of the duties of the President to prepare an address which shall be delivered before the Academy at the annual meeting at which his term of office expires.

The secretary shall have charge of all the books, collections, and material property belonging to the Academy.

Article V. Council.

The Council shall consist of the President, Vice-President, Chairman of each section, Secretary, Treasurer, and the president for the preceding year. To the Council shall be entrusted the management of the affairs of the Academy during the intervals between regular meetings.

Article VI. Standing Committees.

The Standing Committees of the Academy shall be a Committee on Publication and a Committee on Membership.

The Committee on Publication shall consist of the President, the Secretary, and a third member chosen annually by the Academy.

The Committee on Membership shall consist of five members chosen annually by the Academy.

Article VII. Meetings.

The regular meetings of the Academy shall be held at such time and place as the Council may designate. Special meetings may be called by the Council and shall be called upon written request of twenty members.

Article VIII. Publication.

The regular publications of the Academy shall include the transactions of the Academy and such papers as are deemed suitable by the Committee on Publication.

All members shall receive gratis the current issues of the Academy.

Article IX. Affiliation.

The Academy may enter into such relations of affiliation with other organizations of appropriate character as may be recommended by the Council and be ordered by a three-fourths vote of the members present at any regular meeting.

Article X. Amendments.

This constitution may be amended by a three-fourths vote of the members present at an annual meeting, provided that notice of the desired change has been sent by the Secretary to all members at least twenty days before such meeting.

BY-LAWS

I. The following shall be the regular order of business:

1. Call to order.
2. Reports of officers.
3. Reports of standing committees.
4. Election of members.
5. Reports of special committees.
6. Appointment of special committees.
7. Unfinished business.
8. New business.
9. Election of officers.
10. Program.

Adjournment.

II. No meeting of the Academy shall be held without thirty days' previous notice being sent by the Secretary to all members.

III. Fifteen members shall constitute a quorum of the Academy. A majority of the Council shall constitute a quorum of the Council.

IV. No bill against the Academy shall be paid without an order signed by the President and Secretary.

V. Members who shall allow their dues to remain unpaid for three years, having been annually notified of their arrearage by the Treasurer, shall have their names stricken from the roll.

VI. The Secretary shall have charge of the distribution, sale, and exchange of the published Transactions of the Academy, under such restrictions as may be imposed by the Council.

VII. The presiding officer shall at each annual meeting appoint a committee of three who shall examine and report in writing upon the account of the Treasurer.

VIII. No paper shall be entitled to a place on the program unless the manuscript or an abstract of the same shall have been previously delivered to the Secretary.

IX. These by-laws may be suspended by a three-fourths vote of the members present at any regular meeting.

LIST OF MEMBERS

HONORARY MEMBER

Trelease, Wm., LL.D., Mo., Bot. Garden, St. Louis, Mo. (Botany.)

CORRESPONDING MEMBERS

Abbott, J. F., A.M., Washington Uni., St. Louis, Mo. (Zoology.)
Coulter, S. M., Ph.D., 3883 Juniata St., St. Louis, Mo. (Botany.)
Eycleshymer, A. C., Ph.D., St. Louis Uni., St. Louis, Mo. (Anatomy.)
Lyon, E. P., Ph.D., St. Louis University, St. Louis, Mo. (Physiology.)
Turner, C. H., Sumner H. S., St. Louis, Mo. (Invertebrate Zoology.)
Widman, O., Ph.D., 5105 Morgan St., St. Louis, Mo. (Ornithology, Bot.)

ACTIVE MEMBERS

*Abbott, G. A., A.M., 945 Marquette Building, Chicago. (Ornithology.)
Ackert, J. E., A.B., University of Illinois, Urbana. (Zoology.)
*Adams, C. C., Ph.D., University of Illinois, Urbana. (Biology.)
Akeley, C. E., Field Museum, Chicago. (Taxidermy.)
*Andrews, C. W., A.M., The John Crerar Library, Chicago. (Sci. Biblio.)
*Atwell, Chas. B., Ph.M., Northwestern Uni., Evanston. (Botany.)
*Atwood, W. W., Ph.D., University of Chicago, Chicago. (Geology.)
Babcock, Oliver B., M.D., 1100 S. 2nd St., Springfield. (Physician.)
*Bachmann, Frank, State Water Survey, Urbana. (Chemistry.)
Baer, Carlyle, Chicago Academy of Sciences, Chicago. (Natural Hist.)
Bagg, R. M., Jr., Ph.D., University of Illinois, Urbana. (Geology.)
Bagley, W. C., Ph.D., Uni. of Ill., Urbana. (Educational Psychology.)
*Bain, H. Foster, Ph.D., 667 Howard St., San Francisco, Cal. (Geology.)
Bain, Walter G., M.D., Prince Sanitarium, Springfield. (Bacteriology.)
Baird, Miss Grace J., A.B., 608 S. Mathews Ave., Urbana. (Biology.)
Baird, Leo P., A.B., (Eugenics.) Address unknown.
Baker, Chas. L., B.S., Uni. of Chi., Chicago. (Paleontology & Geology.)
Baker, Frank C., Chicago Academy Sciences, Chicago. (Conchology.)
Baker, I. O., C. E., 702 W. University Ave., Champaign, (Civil Eng.)
*Balke, Clarence W., Ph.D., Uni. of Illinois, Urbana. (Chemistry.)
Barber, E. H., address unknown.
Barker, Perry, Box 3024, Ann Arbor, Mich.
*Barnes, Frank G., D.D., Ann Arbor, Mich. (Ethnology.)
*Barnes, H. O., A.B., High School, Springfield. (Mathematics.)
Barnes, R. M., LL.B., Lacon. (Oology.)
Barnes, Will F., M.D., Decatur. (Medicine.)
Barrett, J. T., Cornell University, Ithaca, N. Y.
Barrows, H. H., University of Chicago, Chicago.
*Bartow, Edward, Ph.D., University of Illinois, Urbana. (Chemistry.)
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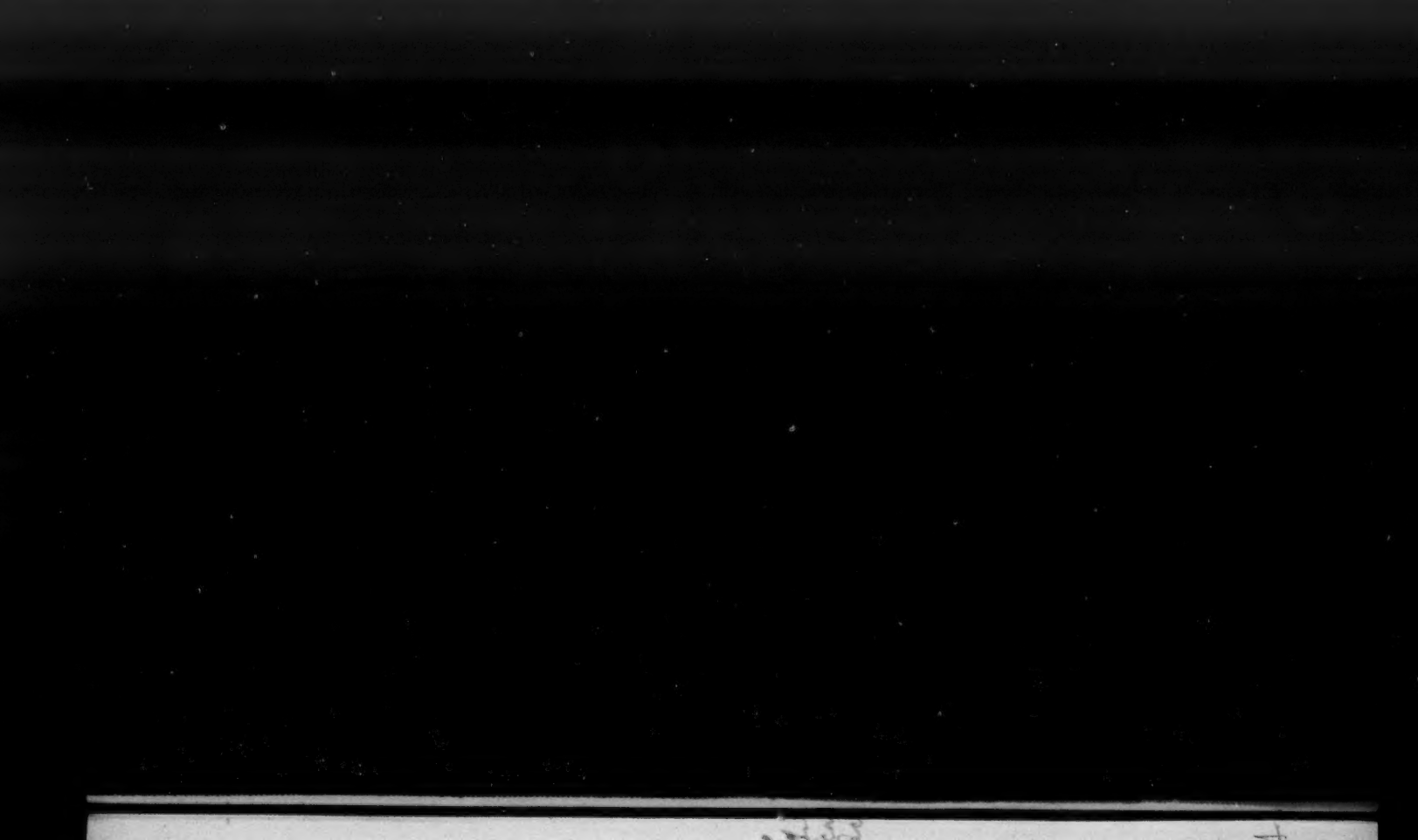

COMPARATIVE TABLE

(1) The total number of hours* (periods)* wo
(2) The courses in science by years.

Township High Schools.	Total No. periods ("hrs.") offered in all departments.	Total periods ("hrs.") offered in each department.									First Year
		Foreign language.	English.	History.	Mathematics.	Commercial.	Science (pure.)	Dom. Science.	Man. Training.	Agriculture.	
Savanna	117	30	16	15	12½	21½	20	..	2	....	Physiology Phys. Geog
Pontiac	127½	30	20	20	17½	20	20	..	....	....	Phys. Geog Physiology
Streator	180	45	20	20	20	30	20	15	10	....	Phys. Geog Dom. Scie
New Trier	237	75	20	20	20	40	25	12	20	....	Phys. Geog Dom. Scie
Sterling	135	45	20	15	17½	5	32½	..	....	....	Biology .. Phys. Geog Physiology
Geneseo	124	30	20	15	15	15	21	4	4	....	Phys. Geo
Evanston	155	65	15	20	20	....	25	..	10	....	Phys. Geo Physioloy
Waukegan	195	50	20	15	15	35	25	10	10	....	Phys. Geog Dom. Scie
Centralia	165½	30	20	20	15	35	22½	20	....	....	Phys. Geo Gen. Sci Dom. Scie
La Salle	240	65	20	15	17½	30	32½	20	20	20	Gen. Scie Phys. Geo Physiology Dom. Scie
La Grange	150	45	20	15	17½	10	22½	..	20	....	Botany ..
Murphysboro ..	124	40	20	20	15	....	20	6	3	....	Physiology Phys. Geo Dom. Scie
Joliet	245	95	30	30	25	20	42½	..	....	2½	Phys. Geo
Marshall	115	35	20	15	15	10	20	..	....	....	Physiology Phys. Geo
Gibson	100	25	20	15	15	10	15	..	....	....	Physiology
De Kalb	142½	35	20	20	17½	20	20	5	....	5	Agricultur Zoology .. Physiology Dom. Scie
Oak Park	182½	65	20	20	20	15	25	..	17½	....	Gen. Scie
Princeton	160	40	20	15	15	30	30	5	....	5	Phys. Geo Physiology
Ottawa	187½	70	20	10	15	25	27½	10	10	....	Gen. Scie
Clyde	.....	..	..	....	....	....	20	..	....	....	Phys. Geo
Lockport	200	30	20	12½	27½	30	35	20	20	5	Botany . Phys. Geo Physiology Dom. Sci

TABLE OF HIGH SCHOOLS, SHOWING:

ods)* work offered in all departments and in each department;

COURSES IN SCIENCE BY YEARS.

First Year.	Semesters.	Periods per w'k.	Second Year.	Semesters.	Periods per w'k.	Third Year.	Semesters.	Periods per w'k.	Fourth Year.	Semesters.	Periods per w'k.
Physiology	1	7	Zoology	1	7						
Phys. Geog.	1	6	Botany	1	7	Chemistry	2	7	Physics	2	7
Phys. Geog.	1	5	Zoology	1	7	Physics	2	5			
Physiology	1	5	Botany	1	7				Chemistry	2	5
			Botany	1	7	Physics	2	7			
Phys. Geog.	1	5	Zoology	1	7	Physiology	2	1	Chemistry	2	7
Dom. Science ...	2	5	Dom. Science ...	2	5	Dom. Science ...	2	5			
			Botany	2	7						
Phys. Geog.	2	7	Dom. Science ...	2	5	Chemistry	2	7	Physics	2	7
Dom. Science ...	2	5	Zoology	2	7	Dom. Science ...	2	5	Dom. Science ...	2	5
Biology	2	10									
Phys. Geog.	1	5	Botany	2	10	Physics	2	7	Chemistry	2	8
Physiology	1	5	Zoology	2	10				Astronomy	1	5
			Zoology	1	..	Botany	2	..			
Phys. Geog.	2	..	Physiology	1	..	Physics	2	..	Chemistry	2	..
			Dom. Science ...	..	..	Dom. Science ...	..	..			
Phys. Geog.	1	5	Botany	2	7½				Physics, or	2	7
Physioloy	½	5	Zoology	2	7½				Chemistry	2	7
			Zoology	2	8						
Phys. Geog.	2	7	Botany	2	8	Physics	2	7	Chemistry	2	7
Dom. Science ...	2	10	Dom. Science ...	2	10						
Phys. Geog. & Gen. Science ..	2	..	Dom. Science ...	2	..						
			Zoology	1	..	Physics	2	..	Chemistry	2	..
Dom. Science ...	2	..	Botany	1	..	Dom. Science ...	2	..	Dom. Science ...	2	..
			Physiology	1	..						
Gen. Science ...	1	10	Biology	2	10				Chemistry	2	10
Phys. Geog.	1	10	Botany	2	16	Physics	2	10	Chemistry	2	10
Physiology	1	5	Zoology	2	10	Dom. Science ...	..	..	Agriculture	..	..
Dom. Science ...	2	10	Dom. Science ...	2	10				4 yr. course.		
						Chemistry	2	5			
Botany	2	5	Zoology	2	5	Phys. Geog.	1	5	Physics	2	5
Physiology	1	7	Zoology	1	7						
Phys. Geog.	1	7	Botany	1	7	Chemistry	2	7	Physics	2	7
Dom. Science ...	2	3	Dom. Science ...	2	3						
						Physics	2	..	Adv. Physics	2	..
						Adv. Botany	1	..	Chemistry	2	..
Phys. Geog.	2	..	Botany	2	..	Zool. & Physiology	2	..	Chemistry Inorg.	2	..
						Agronomy	1	..	Geol. & Astron...	2	..
Physiology	1	5									
Phys. Geog.	1	5	Biology	2	7	Chemistry	2	7	Physics	2	7
						Zoology	1	..			
Physiology	2	5				Botany	1	..	Physics	2	..
Agriculture	1	..	Agriculture	1	..						
Zoology	1	..	Botany	1	..						
Physiology	1	..	Phys. Geog.	1	..	Physics	2	..	Chemistry	2	..
Dom. Science ...	2	3	Dom. Science ...	..	..						
						Botany	2	7			
Gen. Science	1	7	Phys. Geog.	1	7	Zoology	2	7	Chemistry	2	7
						Physics	2	7			
			Zool. & Bot.	2	7						
Phys. Geog.	1	5	Botany	2	7	Physics	2	7	Chemistry	2	7
Physiology	1	5	Agriculture	2	7	Dom. Science ...	2	8			
						Phys Geog.	2	5			
Gen. Science ...	2	3	Botany	2	..	Chemistry	2	7	Physics	2	7
			Zoology	2	..	Dom. Science ...	2	..	Dom. Science ...	2	..
Phys. Geog.	2	5	Zoology	2	6	Physics	2	8	Chemistry	2	8
Botany	2	7							Physics	2	7
Phys. Geog.	1	6	Geology	1	5	Agriculture	2	7	Surveying	1	7
Physiology	1	5	Zoology	1	7	Chemistry	2	7	Astronomy	1	7
Dom. Science ...	2	4	Dom. Science ...	2	4	Dom. Science ...	2	4	Dom. Science ...	2	4

City and Village High Schools.	Total No. periods offered in all departments.	Total periods ("hrs.") offered in each department.									First Year.	Semesters.
	**	Foreign language.	English.	History.	Mathematics.	Commercial.	Science (pure.)	Dom. Science.	Man. Training.	Agriculture.		
Alton	125	40	20	15	15	10	25	....	....	..	Phys. Geog.	1
											Physiology	1
Aurora	160	35	20	20	20	20	20	10	10	..	Phys. Geog.	2
											Dom. Science ..	...
Canton	132½	30	20	20	15	20	27½	....	....	..	Phys. Geog.	2
											Physiology	1
Champaign ..	150	35	20	15	15	35	20	....	10	..	Physiography ..	1
											Phys. Geog.	1
Charleston ..	112½	20	20	12½	15	7½	20	7½	10	..	Phys. Geog.	1
											Botany	1
											Dom. Science ..	2
Clinton	133	30	20	15	17½	20	22½	8	....	..	Physiology	2
											Botany	1
											Dom. Science ..	2
Belleville	.....	..	..	....	....	....	22½	....	....	..	Physiology	2
											Phys. Geog.	1
Elgin	172½	35	20	15	17	20	27½	5	10	..	Physiology	1
											Phys. Geog. ...	2
											Dom. Science ..	2
Galesburg	123	25	20	15	15	25	15	3	5	..	Zoology	1
											Botany	1
											Physiology	1
Mattoon	107½	30	20	17½	15	5	20	....	....	..	Physiology	1
											Phys. Geog. ...	1
Danville	170	45	20	25	15	35	25	5	....	..	Phys. Geog.	2
											Dom. Science ..	2
Moline	175	40	20	15	17½	30	25	6	25	..	Botany	2
											Physiology	1
											Dom. Science ..	2
Freeport	187½	35	20	10	17½	35	20	20	20	10	Bot. or Zool. ..	2
											Dom. Science ..	2
											Agriculture	2
Decatur	137½	45	20	20	20	10	22½	....	....	..	Phys. Geog.	1
											Physiology	1
Pekin	140	40	20	15	15	30	17½	....	....	..	Phys. Geog.	1
Rockford	175	45	20	15	17½	30	27½	....	15	..	Phys. Geog. & ..	...
											Physiology ...	2
Springfield ...	200	55	20	20	20	20	25	20	20	..	Physiology	1
											Phys. Geog.	1
Watseka	120	20	20	10	10	20	20	5	5	..	Phys. Geog.	1
											Botany	1
Peoria	185	65	20	15	20	35	20	....	10	..	Phys. Geog. ...	1
Kewanee	137½	35	20	15	17½	30	20	7½	....	..	Physiology	1
											Phys. Geog.	1
Paris	100	30	20	10	15	5	20	....	....	..	Phys. Geog. ...	1
											Physiology	1
Chicago	191	91	16	20	14	26	24	?	....	..	Physiology	½
											Phys. Geog.	1½

Note: The utmost care has been taken in compiling this table to insure accuracy, but the auth
omitted from the courses of study, or was given in such a manner that it was not easy for a stran
* For the sake of comparison double laboratory periods and all work on laboratory basis are
for one year constitute a course as usually given.
** The amounts given in this column do not include the special studies such as drawing, music,

COURSES IN SCIENCE BY YEARS.

	Semesters.	Periods per w'k.	Second Year.	Semesters.	Periods per w'k.	Third Year.	Semesters.	Periods per w'k.	Fourth Year.	Semesters.	Periods per w'k.
..	1	4	Botany	1	4	Physics	2	7	Chemistry	2	7
..	1	4	Zoology	1	4				Geology	1	4
									Astronomy	1	4
.	2	7	Botany	1	7	Chemistry	2	7	Physics	2	7
.	...	..	Zoology	1	7						
			Dom. Science ...	..	..						
..	2	..	Botany	1	..	Physics	2	..	Chemistry	2	..
..	1	..	Zoology	1	..	Geology	1	..			
						Astronomy	1	..			
..	1	5	Biology	1	7	Physics	2	7	Chemistry	2	7
..	1	7	Physiology, or ..	1	7						
			Physiology	1	5						
..	1	..	Zoology	1	..	Chemistry	2	..	Physics	2	..
.	1	..	Physiology	1	..				Dom. Science ...	2	2
.	2	2	Dom. Science ...	2	2						
..	2	5	Phys. Geog.	1	5	Chemistry	2	7	Physics	2	7
..	1	7	Zoology	1	7	Dom. Science ...	2	4	Dom. Science ...	2	4
	2	4	Dom. Science ...	2	4						
..	2	5	Botany	2	5	Chemistry	2	7	Physics	2	7
	1	5									
.	1	5	Botany	2	7	Chemistry	2	8	Physics	2	8
.	2	5	Zoology	2	7						
..	2	7									
..	1	..	Physics	2	..	Chemistry	2	..			
.	1	..	Dom. Science ...	2	..	Dom. Science ...	2	..			
.	1	..									
..	½	5	Zoology	1	7	Chemistry	2	7	Physics	2	7
..	1	5	Botany	1	7						
..	2	5	Botany	2	5	Physics	2	8	Chemistry	2	8
	2	5				Zoology	2	5			
..	2	7	Zoology	2	7	Chemistry	2	7	Physics	2	7
..	1	3	Phys. Geog.	1	5						
	2	4	Dom. Science ...	2	4						
.	2	..	Zool. or Bot.	2	..	Physics	2	..	Chemistry	2	..
..	2	..	Dom. Science ...	2	..	Dom. Science ...	2	..	Dom. Science ...	2	..
..	2	..	Agriculture	2	..						
..	1	5	Zoology	1	7	Chemistry	2	7	Physics	2	7
..	1	5	Botany	1	7				Astronomy	1	5
..	1	..	Biology	2	..	Physics	2	..	Chemistry	2	..
..	...	..	Botany	2	7	Zoology	2	7	Chemistry	2	7
..	2	5	El. Chem. &			Physics	2	7	Astronomy	1	5
			Dom. Science ...	2	3	Dom. Science ...	2	3			
..	1	5	Zoology	1	10	Physics	2	7	Geol. & Astron...	2	5
..	1	5	Botany	1	10				Chemistry	2	7
..	1	6	Zoology	1	8	Physics	2	7	Chemistry	2	7
..	1	7	Physiology	1	6						
..	1	..	Zoology	1	7	Physics	2	7	Chemistry	2	7
			Botany	1	7						
..	1	..	Zoology	2	..	Chemistry	2	..	Physics	2	..
..	1	5	Dom. Science ...	..	..				Dom. Science	2	..
..	1	5	Botany	1	7	Chemistry	2	..	Physics	2	7
..	1	5	Zoology	1	7						
..	½	4	Botany & Zool. ..	2	6	Physics	2	6	Chemistry	2	6
..	1½	6	or						Geology	1	4
			Botany	2	6				Astronomy	1	4
			Zoology	2	6						

t the author is conscious that there may be some errors. Often the information sought was either or a stranger to interpret it or gather just the information needed.
basis are reduced to equivalent recitation periods. Five recitation periods ("hours") per week

ng, music, rhetoricals, etc., for which many schools give credits.